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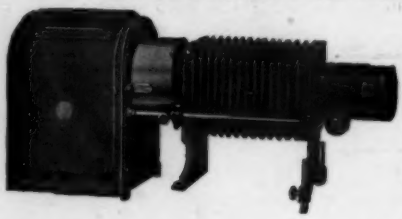

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVIII, No. 6 JUNE, 1918 WHOLE No. 152

THE INFLUENCE OF HIGH SCHOOL BIOLOGICAL COURSES UPON GRADES OF UNIVERSITY FRESHMEN IN ZOOLOGY.

BY H. J. VAN CLEAVE,

Department of Zoology, University of Illinois.

Attention has been called recently to the lack of influence of specific high school units upon marks of college students. Professor Charters[1] has, in a striking manner, presented facts relative to the influence of high school German upon the grades of students in a university class in the same subject. His data were from grades in a second course in German in the University of Missouri. For entrance to this course one semester of elementary German in the university or two years of high school German were required. An analysis of the distribution of the grades showed that those who offered one semester of college German received, on the average, better grades than those who had taken two years of German in high school. The results of this investigation were so suggestive that it seemed worth while to the present writer to present some data along the same general line, dealing with the correlation between high school work in biological courses and marks in a university course in zoology.

It is a common impression among college teachers of zoology that biological work done in the high schools has but little, if any, influence upon the character of the work done by students in college zoology. While this impression has been very general, there do not seem to have been many attempts either to prove the fallacy of the contention or to offer actual data in its support.

In connection with the instruction in general zoology at the University of Illinois, the writer has had opportunity of examining the records of students in university zoology in a critical manner. This subject in the institution under consideration is open to those who have had no high school zoology, as well

[1] Charters, W. W., *School and Society*, 7:119-120.

as to those who have had a course in the high school. In fact, the two groups are not even separated into different sections of the class. By securing information regarding the amount of and nature of the high school sciences offered for entrance credit by individual students, it has been possible to make a direct comparison between the grades in college zoology made by students who have had various combinations of biological courses and those of students who have had no preparatory course in the biological sciences.

In an earlier paper the writer has shown[2] that in the course under consideration there is a striking lack of uniformity in the grade of work done by students in the various years of the college course. For this reason, chiefly, it has seemed desirable in this study to confine the attention to records of those students who have been registered in general zoology during their first year of university work. Data have been gathered covering a period of approximately three years. In another paper[3] the writer has demonstrated that the standards of grading used in this course have been sufficiently uniform to warrant the consideration of grades from various years' work being assembled in the consideration of mass data. Grades and high school records of 174 freshmen in general zoology have been brought together in the course of this study. Of these, 103 had credit for at least one-half year of high school zoology; 23 of this same group had no credit for high school botany, while the remaining 80 were students who had taken both zoology and botany in high school. Seventy-one who had earned no credit in zoology before entering the university comprised 49 who had taken neither botany nor zoology and 22 who had taken botany but no zoology.

TABLE I.—AVERAGE GRADES OF FRESHMEN IN UNIVERSITY ZOOLOGY.

Biological Courses in High School.	No. of Students.	FINAL GRADE Av.	FINAL GRADE Median.	QUIZ GRADE Av.	QUIZ GRADE Median	LAB. GRADE Av.	LAB. GRADE Median
Zoology and botany	80	78	78.5	79.9	80	79.5	80
Zoology only	23	79	80	80.1	80	80.1	80
Total having zoology	**103**	**78.2**	**79**	**79.8**	**80**	**79.6**	**80**
Botany only	22	76.2	77	80.5	83	77.3	80
Neither botany nor zoology	49	75.2	75	77.2	78	76.8	78
Total having no zoology	**71**	**75.7**	**76**	**78.2**	**80**	**77**	**78**

From Table I it appears that the advantage gained by those having had high school zoology over those not having had it is practically negligible as far as influencing the final average and median grades of the two groups in university zoology is con-

[2] Van Cleave, H. J., *School and Society*, 5:356-360.
[3] Van Cleave, H. J., *Educational Administration and Supervision*, 2:251-253.

cerned. By closer analysis of the data, bringing together those who have had similar biological training in high school, it becomes apparent that those who have taken both botany and zoology average less than three points higher in university zoology than those who have taken neither botany nor zoology in high school. This difference is unfortunately small. In fact, it is so small a difference that any method of expression other than an arithmetical average of per cent grades would classify these two groups of students as doing work of equal merit, regardless of their difference in previous training. In general, the same lack of sharp separation between the two groups applies to the average grades in both laboratory and quiz.

In an earlier paper,[2] referred to above, the writer has demonstrated that students may show broadly varying degrees of proficiency in laboratory work and in oral quiz. Of these the latter is based chiefly upon content of lectures and text assignments, and consequently does not involve the exercise of many of the operations and procedures which are peculiar to the biological sciences. If high school work in zoology provides a training in scientific method and laboratory manipulation, the results of this training should be reflected in the superior laboratory work of students in the university who have had biological training in their preparatory course. An inspection of Table I shows that the average laboratory grade of these students excels that of students who have had no zoology before entering the university by only 2.6 points. That this slight difference is not due to the effect of a few exceptionally low or high marks in either group is demonstrated by the fact that the median grades in the two groups differ by but two points. What is even more unexpected is the fact that those who had had no previous training in the laboratory methods peculiar to biology averaged less than three points lower in laboratory grades than did those who had taken courses in both zoology and botany.

TABLE II.—PERCENTAGES OF FRESHMEN HAVING AVERAGES BELOW 70 IN UNIVERSITY ZOOLOGY.

Biological Courses in High School.	No. of Students.	Per Cent Failure in Course.	Per Cent Below 70 In Quiz.	Per Cent Below 70. In Lab.
Zoology and botany	80	11.3	7.5	7.5
Zoology only	23	13	8.7	13
Total having zoology	**103**	**11.7**	**7.8**	**8.7**
Botany only	22	13.6	0	19
Neither botany nor zoology	49	20.4	20.4	12.8
Total having no zoology	**71**	**18.3**	**14.1**	**14.1**

In connection with the foregoing table it should be mentioned that 70 is considered the passing grade.

On the evidence presented in Table I there seems to be justification of the common impression that those who have had high school zoology do little if any better in the university zoology than those who have had no such course previously. However, a closer analysis of the data as given in Tables II, III, and IV and in Figures 1, 2, and 3 furnishes evidence that there are real differences in the two groups which a mathematical average of the grades fails to bring out. For example, it is quite significant that the total failures in university zoology (Table II) should include but 11.3 per cent of those who have taken both botany and zoology in high school, and 20.4 per cent of those who have taken no high school course in either zoology or botany.

Whether this indicates a difference in ability due to actual increased proficiency in methods and manipulation or is simply the result of eliminating from the university course those who did poorly in biological courses of the high school, remains unproven. A comparison of the percentages of those below 70 in laboratory and in quiz indicates, however, that there is very little difference between the percentages of failure in these two phases of the work.

On the supposition that one might expect to find increased proficiency in laboratory work resulting from experience gained in the high school courses in biology it is hard to explain how 20.4 per cent of those who had neither botany nor zoology in high school did unsatisfactory work in quiz, while but 12.8 per cent of the same group were unsatisfactory laboratory students. Of those who had taken zoology in high school a slightly larger percentage did unsatisfactory work in laboratory (8.7 per cent) than in quiz (7.8 per cent). These results are contrary to the expectation voiced in the opening of this paragraph.

The question arises as to the influence of high school botany upon the character of the work done by students in university zoology. The number of instances wherein students took botany and no zoology in the present study is far too small to be of any great consequence toward establishing the existence of or absence of correlation between methods in the two subjects. The fact remains that of the 22 students who took botany and no zoology in high school, none failed in quiz while 19 per cent

failed in the laboratory phase of the university zoology. That these same students averaged higher in quiz than in laboratory would at least suggest that they did not carry over any great amount of laboratory method from the one science to the other.

TABLE III.—PERCENTAGES OF FRESHMEN HAVING AVERAGE GRADES OF 90 OR ABOVE IN UNIVERSITY ZOOLOGY.

Biological Courses in High School.	No of Students.	Per Cent with Grade of 90 or Above: Final Grade.	Quiz.	Laboratory.
Zoology and botany	80	13.8	16.3	10
Zoology only	23	8.7	8.7	13
Total having zoology	**103**	**12.6**	**14.6**	**10.7**
Botany only	22	9.1	13.6	13.6
Neither botany nor zoology	49	8.2	16.3	0
Total having no zoology	**71**	**8.5**	**15.5**	**5.6**

Taking students who received a final grade of 90 or above as indicating those who did superior work in the entire course (see Table III), 13.8 per cent of those who had both zoology and botany in the high school fall in this group, while only 8.2 per cent of those who had neither zoology nor botany in high school could be classified here. Among these students receiving the highest grades there is an increased ability in laboratory work, apparently due to the high school training, for in the case under consideration 10.7 per cent of those who had taken zoology in high school did laboratory work with a grade of 90 or better in the university, while *no* student among the university freshmen who had taken neither zoology nor botany in high school succeeded in getting a grade of 90 in his laboratory work.

It is rather remarkable that those who had taken a full year of high school zoology did but little better in the university course than the average of all those who had taken any zoology in high school, the majority of whom had taken it for but half a year. From figures not given in the tables it has been determined that the average final grade in university zoology of 24 freshmen who had taken a full year of the subject in high school was 80.5. This means that a full year devoted to zoology in the high school raised the final grade in university zoology only five points above the average for persons having no previous training whatsoever in biological sciences.

A system of literal grades has recently replaced the numerical grading system in the University of Illinois. By a statistical study involving the grades of over 1,000 students who, in the

past five years, have taken the elementary course in zoology, the writer has determined the approximate equivalence of numerical and literal grades for this course. The numerical values assigned to the literal symbols were such that A (Excellent) included about the upper 10 per cent of the entire group of students; B (Good) included the next 30 per cent; C (Fair) about 35 per cent; D (Poor) a small group of about 15 per cent; and E (Failure) about 10 per cent.

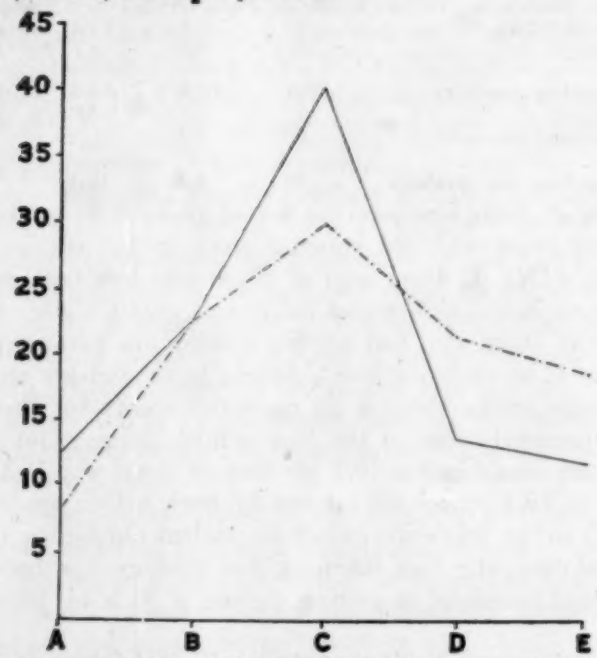

Figure 1. Per cent distribution of final grades of freshmen in university zoology. Solid line represents distribution of final grades of 103 freshmen who had taken high school zoology. Dot and dash line, distribution of final grades of 71 freshmen who had taken no zoology in high school.

TABLE IV.—PER CENT DISTRIBUTION OF GRADES OF UNIVERSITY FRESHMEN IN ZOOLOGY.

	Per Cent A (Excellent)	Per Cent B (Good)	Per Cent C (Fair)	Per Cent D (Poor)	Per Cent E (Failure)
Quiz Grades:					
High school zoology	14.6	24.3	41.7	11.6	7.8
No high school zoology	15.5	22.5	33.8	14.1	14.1
Laboratory Grades:					
High school zoology	10.7	23.3	44.7	12.6	8.7
No high school zoology	5.6	25.3	42.3	12.7	14.1
Final Grades:					
High school zoology	12.6	22.3	39.8	13.6	11.7
No high school zoology	8.5	22.5	29.6	21.1	18.3

These literal grades more nearly conform to a natural classification or grouping of students of like ability without placing undue emphasis upon differences of a few per cent. In fact, such slight differences are immeasurable in actual practice of grading. Table IV shows the distribution of the grades under consideration in this paper on the basis of the literal system.

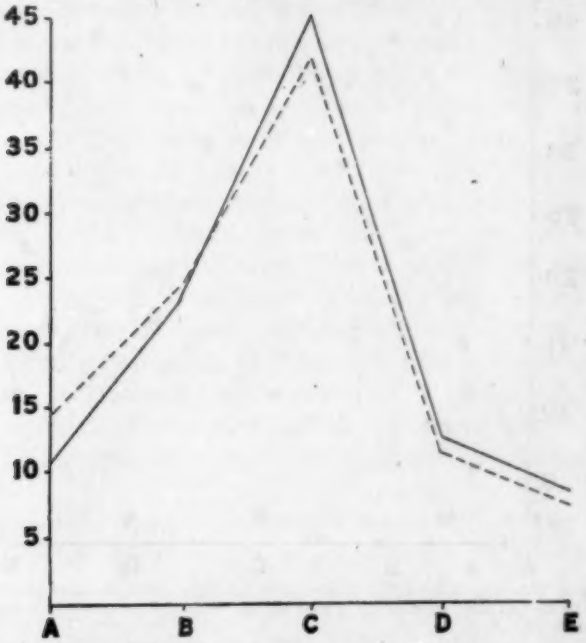

Figure 2. Per cent distribution of laboratory and quiz grades in university zoology for 103 freshmen who had taken zoology in high school. Solid line represents distribution of grades in laboratory; broken line, grades in quiz.

For ready comparison of the grades the data presented in Table IV have been prepared as a series of graphs (Figures 1, 2, and 3). In each of these graphs the scale upon the abscissa represents the literal grades, while the scale upon the ordinate represents the percentage of students in the different groups receiving the grades indicated upon the abscissa.

In spite of the fact that the average final grades for those who had and for those who had not taken high school zoology differed so slightly, the curves for these two groups show that this difference is distributed throughout almost the entire length of the curves.

Figure 2 emphasizes in graphic manner the lack of measurable increased ability in laboratory over quiz resulting from the pursuit of zoology in the high school.

Figure 3 shows that while few students without previous training in the subject were able to do 'excellent' laboratory work, the averages in laboratory throughout the remainder of the group were better than the averages in quiz.

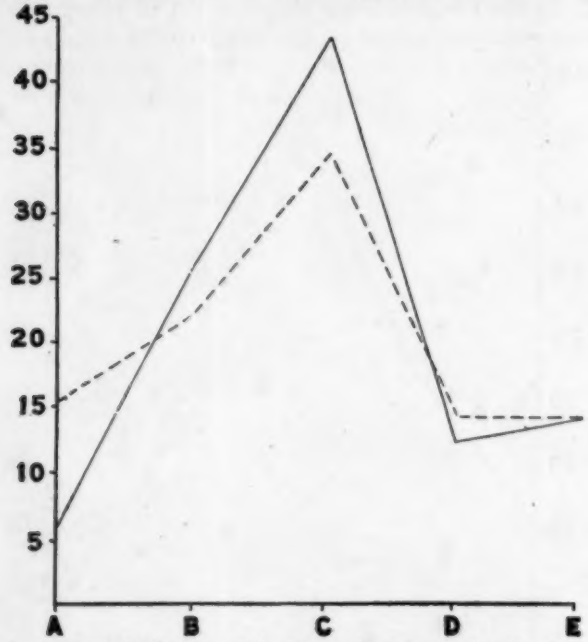

Figure 3. Per cent distribution of laboratory and quiz grades in university zoology for 71 freshmen who had taken no zoology in high school. Solid line, grades in laboratory; broken line, grades in quiz.

Conclusions.

From facts brought out in this paper it may be concluded that the average final grade of freshmen in university zoology is little affected by previous training in biological courses. Taken alone this seems to corroborate an opinion frequently expressed by college and university teachers of zoology, namely, that the study of or omission of zoology in high school has little influence upon the kind of work done by students in this same subject in college or university classes.

As a matter of fact, while the actual difference in average and median final grades in university zoology of students having and those not having high school zoology is slight, it is none the less real since the advantage is distributed among practically all groups of students who have had work in high school biological courses.

The relatively small difference between these two groups of

students indicates in a forceful manner the result of the lack of coordination between high school and university courses in zoology and botany. The majority of those interested in the teaching of the biological sciences realize that there is a lack of standardization of zoology and botany courses in the secondary schools. This lack of standardization is in great measure responsible for the lack of coordination just mentioned. Under these conditions students entering institutions of higher learning have had such varied training in zoology or in botany that usually no attempt has been made to give recognition to the start which they have made in biological work. It is sometimes argued that the greater or less amount of repetition which this procedure involves has an undesirable influence upon the attitude of the students toward their work in the university course. Granted that this may be true, it does not explain why those who have had biological courses in high school show almost negligible increased proficiency in laboratory methods. In fact, an examination of Figures 2 and 3 shows that these students do laboratory and quiz work of practically identical grade, while those who have had no high school zoology produce greater numbers who receive better grades in laboratory than in quiz.

This lack of specific training in scientific methods which in the laboratory work of the biological sciences involves rather distinct types of manipulation and procedure is a point wherein the high school courses in zoology and botany apparently fail to give the training in scientific method which may be logically expected from them.

In connection with these conclusions there are certain facts which must be kept in mind. The writer has considered only the influence of high school biological courses upon *grades* received by university freshmen in zoology. This influence in itself must not be regarded as a measure of the success or failure of biological courses as given in the secondary schools. As brought out earlier in this paper, the lack of specific influence of these subjects upon the grade of work done in the same subjects in university is due in great measure to the lack of correlation between the high school and university courses in biology. The percentage of high school students which goes on into university work is so small that it does not seem expedient that an absolute correlation should be sought. The ultimate aim of high school zoology should be the fitting of its students for better living and greater service to society.

BOTANY LABORATORY EQUIPMENT.

By Willard N. Clute,
Joliet, Ill.

Something seems to be the matter with botany. On all sides we are told that the study meets no real need of the pupil, that its place in the curriculum might better be given to more practical things, and that it is only a matter of time, anyway, until it will come to an end through sheer inanition. A decrease of nearly 50 per cent in registration in the study during the last ten years gives point to these assertions and inclines the advocate of botany in the schools to sit up and take notice.

It is no secret that botany, as taught at present, is fast waning in popularity. The reason for this decline in interest has been sought in various directions without securing any very satisfactory answer. Some explain the situation by the statement that there has been a tremendous shift from botany to agriculture, general science, manual training, and domestic science, but, to my mind, this does not entirely account for the situation. Though the studies mentioned are still so new as to possess the charm of novelty, it is not, I am sure, the novelty alone that attracts. The fact that they present certain phases of education in a more practical way, or at least emphasize the practical aspects of certain studies, has a strong appeal for the pupil. The intelligent student is more than ever inclined to ask what advantages a given course of study will bring him, and, if the advantages are not apparent, to drop it from his list. Botany seems to be one of the studies that have been tried and found wanting. The question then is, what are we going to do about it?

One of the first things that can be done to rehabilitate botany is to give it a more practical turn. There are, to be sure, a number of schools in which the study already has this character but the statement that botany is as yet rather too academic and lacking in practical applications is not likely to be seriously challenged. Too many botany classes are still engaged in the "analysis" of flowers and in herbarium making. Others are giving altogether too much time to the minute anatomy of plants, to the microscopic study of the blue-green algae; to the morphology of mosses and ferns, the alternation of generations, the evolution of spermatophytes, and various other matters that might better be left to the kindly ministrations of college and university.

In citing the studies just mentioned as examples, no criticism

is made of their cultural value. If botany is to continue to be mainly a cultural subject, possibly we should continue to emphasize them, but the teacher of botany is confronted by the stubborn fact that these things do not appeal to the general public. If they did, botany would not be losing ground. What the public wants,—nay, is beginning to demand—is more information regarding foods, fibers, drugs, dyes, woods, and other useful plant products, budding, grafting, plant breeding, Mendel's Law, the adjustments of plants to soil and climate—in short, it wants information on those phases of botany that touch community life, and there does not seem any valid reason why it should not have such information though there are a number of reasons why it does not get it.

One reason for the unpopularity of the course in botany is to be found in the books on the subject. Practically all of these are written by college men; estimable gentlemen, all, but men, nevertheless, who know mighty little about what the public wants (judged by their works) and who, I sometimes suspect, care less. Most of them have been so long out of touch with the youngster of fourteen that the very language they use is not intelligible to him. Nor is the subject presented in such a way as to interest him. It is not contended that children cannot be made to take on enough of the matter provided to pass a creditable examination, but if anybody wants data on how deep such information sinks in, let him inquire how many students of botany are enough impressed with it to continue it after they have left school. The real botanists and botanizers of our country—people who are enough interested in botany to make it an avocation—did not, as a rule, take botany in the schools!

I would be the last person in the world to charge any of the shortcomings of the botanical course to the teachers. In my opinion, they are the most devoted, self-sacrificing and energetic group of people in the schools today. What other teachers, after a full day's work, contribute so much of their time and money to the hunt for specimens to be used in class next day? The teacher of manual training has a well-equipped shop stocked with the materials of his trade; the domestic science teacher is likewise supplied with everything needed by her classes except certain perishables which can be ordered by telephone; the teacher of agriculture is provided with seeds, tools, charts, land, and a laboratory, but the botany teacher still collects his own

materials—or goes without. With the best intentions in the world, the botany teacher is his own greatest enemy. He has rustled for himself so long that boards of education are disposed to let him continue it. Is it any wonder, then, that dried and pickled specimens form the backbone of most botanical courses?

Even the botany teacher often fails to see that his study, with zoology, is sharply set off from all others by the fact that it deals with *living things*. These have their youth, maturity, and old age, their time of growth and of reproduction. They cannot be kept in bottles on the shelf like the materials of the chemist. They must not only be accessible in the living state, but means must be found to have them in the proper condition of maturity required. There should be a collection of plants growing in the open, supplemented by a greenhouse in which various exotics may be cultivated for study in winter. A practical course would also require a museum of various plant products. Of course all these things cost money, but before deciding that they cost more than the school can afford, compare their cost with the expense incurred in fitting up the manual training department, the chemistry or physics laboratory, or the gymnasium. And last, frequent field trips must be conducted if real botany is to be taught. The arrangement of plants in greenhouse and garden is at best artificial. The student needs to see plants as they grow in the wild. I imagine that if the botanical course were adequately equipped and properly manned, we would hear less about the decline in botany. Every teacher who desires the advancement of botanical teaching should consider himself a committee of one to push the claims of botany to an adequate equipment.

And, finally, the teacher of botany should keep a sharp watch on certain phases of general science. Any course in the latter which skims the cream from botany and gives the pupil the impression that he has had botany is a menace. If general science remains *general* science, it will be a help and worthy of encouragement. Properly presented in the first year it will relieve the teacher of a large amount of instruction in the principles upon which his science is founded, but if this study is allowed to arrogate to itself instruction in the elements of botany, then our sorely beset science will the sooner follow the lepidodendron and the cycadofilices into oblivion.

BIOLOGY IN THE HIGH SCHOOL OF TOMORROW.[1]

By Harold B. Shinn,

Schurz High School, Chicago.

One well acquainted with modern schools and school-teachers recently remarked that altogether too often discussion of a school question dropped into unkind and destructive criticism of everything and everybody. We grant this statement, and, having granted it, stand ready to look, not backward to a condition of mental servitude and hero worship, but ahead to a promised land, an immediate future out of which we hope to secure at least a few good things for biology in the high school of today. There are so many factors in the problem of teaching biology that one must analyze them and work from smaller details to larger generalizations.

Those of us who have been watching the changes occurring in viewpoint, motive, or aim are saying that probably the question soon to surge upon us is, "How can we help save human life, and, having saved it, how make living more worth while?" A college man well known for his chemical researches once said to me: "The man who undertakes a research problem which will contribute nothing to better human conditions is a parasite upon society." This statement seemed the more surprising because of him who said it. Biology is going to cut out many topics which contributed little or nothing to human welfare and human happiness in order that it may elaborate others. And those teachers who fail to get this viewpoint will be relegated to the scrap heap. We maintain that in a high school course there is no room for long-winded discussions of the algae, red, green, blue-green, and brown; for taxonomy of ferns and mosses; for anything of echinoderms nor more than cursory treatment of coelenterates; for the fruitless dissection of many forms. In botany there will be more of the planting and care of house plants and grounds, more studies in the ecology of those plants and animals which appear in the landscape and contribute to it, and more study and care of home and farm.

We feel sure that even yet, after several years of "economic" teaching of plants and animals, there remains in the minds of many teachers of academic thought a marked dislike for the word and its use; and we are equally sure that this dislike is caused by the narrow treatment of so-called "economic" forms

[1]Read at the November, 1917, meeting of the Central Association at Columbus, Ohio.

by accepted textbooks. The cabbage butterfly, for example, is truly a noxious insect, yet it illustrates all that any butterfly shows—coloration and sex markings, metamorphosis, dispersal, etc., so that perfectly good zoology can be taught with an injurious form. Textbooks, however, still teach zoology from the poor old locust, who has been so sadly overworked, and set the cabbage butterfly over to a chapter prefaced with a statement of how many million dollars' worth of damage it does annually.

The corn plant is botanical material with a strongly mercenary association, yet it is capable of just as extended treatment as was Huxley's crayfish, which was used for an entire year in his classes. The corn can be utilized to teach the phenomena of soil conditions, growth, food storage, cross- and self-pollination, and seed structure, botany fully as good as that of the lily or the pine. But the corn and all the cereals are usually set back in the book to a chapter prefaced with a statement of the cash value of the various cereals in 1900 B. C. Corn and the cabbage butterfly are but illustrations of a fairly general state of affairs in biology. Yet as educators we stoutly maintain that just as good mental training can be gained from the study of a science, which is sometimes practical, as from the study of a dead and moldy language, which was never very practical but was the hall mark of a scholar.

Therefore there should arise no misunderstanding as to motive. Biology will be economic but not mercenary; its subjects will be taught, not because they add a dollar to nor subtract a dollar from the future income of tomorrow's pupils, but because they will add to the joy and the possibility of living. The commercial courses of today are not educational because their ideal is the dollar. Our motive will be higher than most of us conceive in the word economic; the spirit of altruism and community service will give a deeper life to biology.

With the new viewpoint botany will teach, and should now teach, the principles of soil fertilization, sterilization, and innoculation. There will be more practical work with plants, as forestry, tree planting and tree surgery, pruning, grafting, budding, artificial pollination, and breeding. There will be a wider use of the indoor garden; home gardening and work in the fields will be directed by the school and will be accredited in the botany course, as it is now in many progressive schools. Indeed, the summer vacation will bring, to some extent, merely

a change in laboratory. Briefly, in botany tomorrow there will be less of the book and more of the plant.

In zoology the study of invertebrates will consume not over one-half the time of the course, and that of mammals will become developed until it occupies almost one-fourth the total time. The major classes studied will be mammals, birds, and insects, and, as in botany, some classes will be entirely cut out of the course. There will be greater use of vivaria, indoor and outdoor; the latter, ponds and wooded tracts. In schools without definite courses in agriculture the zoology will incorporate certain phases of animal husbandry so that it will accredit such home projects as beekeeping, poultry keeping, the rearing of pigs and calves, and the spraying of orchard and garden for noxious insects.

While home projects will be many and the zoology course will be extended to include some phases of summer work, yet the classroom and the laboratory will be just as exact as now, if not more so, and a few good dissections will be demanded.

There will be definite work upon home and community sanitation under direction of, or in colaboration with, the local health bureau. There will be better knowledge of native mammals, the eradication of injurious and the conservation of beneficial forms. Here, too, there will be less of the book and more of the animal.

One of the greatest misfits in current education is sex hygiene; the physiologist would hand it to the physical director; the physical director hands it to the zoologist; the zoologist calls for a doctor; the botanist washes his hands of it entirely. We venture to say that tomorrow sex hygiene will not be taught as such, will not be treated as an individual problem, but that it will be approached from the angle of social hygiene, somewhat as follows. Nature conserves her races at least in part by elimination of the unfit; man reverses the act and conserves the idiots, imbeciles, lame, halt, and blind by assuming the burden of penitentiaries, asylums, and orphanages, and eliminates the fit by adding to their burdens, the unfit. The great current of inefficiency sweeps upon us in a constantly increasing stream of illegitimates whose real parents undertake no responsibility. Society will meet this problem face to face and wrestle with it biologically. The botanist will utilize his plant breeding, and the zoologist will use animal reproduction, to teach analogous human relationships. Seed selection presupposes parentage;

stock breeding demands pedigree and type. Social sanitation calls for careful mating, and when the high schools of tomorrow teach that every boy and girl is a potential parent with a parent's responsibilities they will have done all that the most radical sex hygienist ever demanded. Thus biology will be more sociological, not too much, yet enough so that the pupils become good citizens.

If we may conclude anything from the present judgment of teachers in sixty-eight Illinois high schools who recently reported to the State Conference Committee, of which the writer was chairman, in the high school of tomorrow botany and zoology will be one-year courses, and physiology and physiography will be displaced by general science or its posthumous child. Botany and zoology will be given in alternate years.

Each subject will draw subject material from the other more freely than now, so becoming more bio-logical. The preliminary science, perhaps general science, will be more closely and more smoothly articulated with biology than now, and possibly the entire science course will be more unified so that there will be a definitely outlined series of subjects, each requiring a preceding one and each definitely contributing to a successor. Such a condition can come about only through closer supervision of the work and the appointment of a department head. A zoological principle must be followed—"specialization leads to cephalization."

Biology teachers are quite generally agreed that the weakest spot in their teaching today is in the manipulation of the laboratory. We forecast that the change in viewpoint and changes in material will alter our laboratory methods and solve this problem with which we are now wrestling. Less will be done for classes, but they will do more for themselves; the laboratory lesson will be partly prepared before appearance in class; the notebook will be less voluminous, the drawings limited to matter not to be discovered elsewhere than in the specimen, and the notes not to be formulated except by the pupil himself. Mere repetition of trivial observation or verification of common knowledge will be tabooed. The laboratory will be in part a museum and, in part, a workroom equipped with aquaria, vivaria, living birds and insects, growing plants and growing minds.

The biology of tomorrow will demand tomorrow's teachers. In biology more than in any other subject does the teaching

depend up on the special training of the teacher; in other words, too often does the high school pupil receive instruction in only those things which the college or university decrees its students should get; soon these students begin to teach these topics to immature high school classes. They, in turn, fail to comprehend their work and grow to dislike it, until botany and zoology fail to attract many pupils or to contribute much to their development. In most of the larger cities, however, and in some smaller ones, biology teaching has been making long and rapid strides, so that now the pedagogy of high school botany and zoology has advanced quite beyond that of the university, and the university is now a drag upon the high schools. The failure of the colleges properly to instruct their outgoing graduates who have sought teacher's training is now the greatest obstacle in the advancement of high school biology.

This bitter arraignment of the university is running through the minds of hosts of high school teachers in many subjects. Repeatedly have they sent up cries for special training, the last having been at the Illinois Conference in Champaign, November 24, 1917. The Biology Section of the Central Association of Science and Mathematics Teachers in Des Moines four years ago resolved that the universities should do this thing, train prospective teachers in the content and aim of the high school course. As long as the college fails to hear this call, so long will the high school struggle on with its burden of poorly trained teachers and teachers out of sympathy with their environment.

The university further maintains its strangle hold upon high school biology through its domination of the textbook. Book publishers too long have followed the phantom that only college professors can write books. The texts in widest use today are those prepared by men actually in secondary teaching, or most nearly in touch with it. Our text will be written by high school teachers who will be ten or twenty years in advance of their time as to viewpoint, in the high school of tomororw, and the universities will no longer impose their neomonastic training upon us, but we shall both advance, abreast, both working for racial and social improvement and the conservation of those things which make life worth while.

LABORATORY STORAGE AND FILING APPLIANCES.

By W. L. Eikenberry,
University of Kansas, Lawrence.

The safe and convenient storage of apparatus and supplies is always a problem. Some of the newer laboratories are generously provided with cases, drawers, storerooms, and special devices, but even here there is commonly a demand for additional space or for provision for storage of articles not taken into account by the architect. In the smaller schools and older buildings the problem is often one of the most serious that meets the teacher.

The efficiency of teaching is dependent upon proper storage of materials to a very considerable extent. If the teacher of a laboratory subject is to be free to give the proper amount of time and attention to the essential teaching problems, his time must not be monopolized by the routine work of getting out, setting up, and putting away apparatus. It should be possible for the teacher to put his hand upon any needed article at any time and without search. This means, of course, the storage of the numerous impedimenta of a laboratory in a large number of small units, preferably drawers, instead of tumbling them together miscellaneously in a few large drawers. It means that cork stoppers of the several sizes, rubber stoppers, rubber tubing, short pieces of glass tubing, tools, pinch cocks, pulleys, wire, screws, nails, staples, weights, clamps, burners, ad infinitum, should each have their separate and labeled location. It means that in a biological laboratory each sort of seed, twig, wood section, shells, soil samples, etc., must be readily at hand either for illustrative purposes or as a supply of materials for laboratory work. If the teacher can know absolutely that the materials for the laboratory study to be made by the class next day are in their proper places ready to be set before the class in the morning, hours of search and preparation may be saved in the preceding afternoon for recreation or for study. Such conditions can be achieved only with adequate provision for systematic storage of materials. No school board can afford to allow a teacher who is capable of teaching to spend his time on non-constructive routine that can be avoided by provision of proper facilities.

The essentials of a proper storage system are many. In the first place, it must provide for a great variety of objects. Shelves are suitable for bottles and for certain types of apparatus. Large drawers are useful for a few things, though they are much

less useful than architects seem to think them. The small objects which ordinarily litter up tables, shelves, and drawers in cigar boxes, thread boxes, and paper bags, or lie around loose, always in the way excepting when they are wanted, can be stored satisfactorily only in drawers of size comparable to card catalog drawers. Maps and charts require either special cases or wide, shallow drawers.

A satisfactory system will be elastic in that it is possible to increase it as the laboratory grows and as the school can afford the investment. This is particularly important in the case of small schools, or schools in which only minimum provision for laboratory work was made when the building was constructed. Such elasticity not only allows the storage facilities to grow as rapidly as the need becomes apparent, but also allows these facilities to keep pace with the character of the demand as the courses grow or change.

Lastly, it is important for the purposes of most schools that the type of device adopted be one that is a commercial product rather than a special design, and therefore readily procurable at any time and at minimum cost. Special designs are always much more expensive than commercial goods, since the latter may be manufactured in quantity. Furthermore, special designs often cannot be secured when wanted.

Laboratory supply companies put out a good line of special laboratory furniture. Some articles, as the tables, can hardly be satisfactorily substituted by any commercial product, but the storage cases are commonly large and expensive, and do not afford much variety in the facilities offered. So far as the writer is aware, no laboratory supply company offers a case combining several sizes of small drawers, and thus suitable for general purposes in a small laboratory.

The obvious need has caused the writer to examine lines of commercial office equipment in the search for equipment adaptable to laboratory use. It has been found that much of the office furniture is well suited to laboratory purposes. Whenever so adaptable it offers the advantages of lower price due to quantity production, very considerable variety in the type of the devices, and the great elasticity due to sectional construction.

For the purposes of the Training School at the University of Kansas a horizontal unit, forty-two inches wide, has been adopted as the standard. For the storage of small objects we are using 18-drawer 3x5 card files and 12-drawer daily report

files. The former contains in each section eighteen drawers with inside dimensions of 3½ x 5⅛ x 14½ inches. At our request the manufacturers made up the card drawers with solid bottoms and full height sides, but without rod and follower block used for cards. The charge for this change was nominal. The daily report drawers measure 3¼x8½x14 inches and are used as manufactured, no special work on them being necessary. The line of devices offered includes drawers of similar character, ranging from one and three-fourths to five inches deep, and up to eighteen inches wide, requiring no change to adapt them to laboratory storage purposes. Doubtless 4x6 and 5x8 card file drawers could be modified as were the 3x5 drawers if it were desired. The sections can be intermembered, of course, in any manner desired. In comparison with special cases of drawers offered as laboratory furniture and containing nearly a hundred small drawers, the saving in price appears to be about forty per cent. The greatest advantage lies in the fact that the sections secured fit our needs more exactly than would be true of any single type of drawer even though manufactured especially for laboratory use. Also, the fact that it was possible to start with a small investment allowed the immediate purchase of other needed laboratory furniture, which could not have been secured for a year or more if a large amount of money had been tied up in a single storage case.

For the storage of maps and charts there is available the type of office devices that are made for the storage of blue prints. Doubtless the best of these is a file that takes very large sheets in envelopes in vertical position after the manner of the vertical filing of correspondence. However, it is rather too expensive for most schools. A satisfactory device for medium sized maps may be secured in the form of a horizontal section uniform with those described above and offering drawers with inside dimensions of 2½ x 38 x 24½ inches, with four such drawers in a section.

The blue print drawers and the somewhat similar legal blank and insurance policy drawers of the deeper styles may be provided with cork bottoms and glass covers, and are then suitable for use as insect cabinets. This adaptation may be made in the school shops. Such use is now being made of them in the museum of the School of Education of the University of Chicago. All of these styles would also be readily usable for the storage of small specimens of rocks, minerals, lichens, wood sections, and other small class or display materials, and these can be provided

with glass covers or not as the needs of the particular situation dictate.

It is scarcely necessary to call attention to the convenience of shelving the laboratory library in book sections in the same stacks, if desired.

Laboratory outlines, manuscript notes, blank paper supplies, and other miscellaneous materials of this character are best stored in vertical letter file drawers, three such drawers occupying a section. The use of tabbed folders will make it possible to keep together errant sheets of data on the same subject as a business house keeps together correspondence with one individual. Pictures mounted on ordinary 8x10 letter paper or on cards of that size are conveniently filed in the same manner. Of course for all of these purposes an abundance of guides, after the manner of guides in card catalogs, is necessary to facilitate quick reference.

The storage of pamphlets, such as the bulletins of the Department of Agriculture, is another matter that engages attention. Vertical filing is ideally adapted to caring for these publications. They may be stored on edge in letter file drawers much as cards are stored in card drawers. They will then be kept flat and preserved from dust and light, but at the same time be ready for instant consultation. They should be placed in such position that the back titles, if any are printed, will be readable, and that the title on the front cover can be seen by separating them slightly as one does with cards when consulting them. If the publications are grouped by subject in accordance with some system of classification, and a sufficient number of guides are used, no index to the bulletins is necessary. If classification numbers pertaining to the system used are placed upon both the guides and the pamphlets, it becomes very easy for a pupil assistant or other unskilled helper to return bulletins to their places in the file with accuracy. Catalogs and students' notebooks may also be cared for in the same manner.

While horizontal units containing vertical filing drawers as described above may be used for filing pamphlets, it is usually advisable, in the interest of economy, to use a slightly different style of unit. Vertical units, containing a larger number of drawers, are commonly supplied at a lower cost per drawer than horizontal units. Either the letter file or the invoice file may be used for pamphlets, though neither is exactly the right size for this service. A vertical letter file unit commonly contains four

drawers with inside dimensions of 12⅛ inches wide and 10½ inches high. The width is satisfactory, but the height is somewhat greater than necessary, with consequent loss of space. An invoice file unit contains five drawers 8¼ inches high by 10 inches wide. This gives the advantage of five drawers instead of four, and the height is great enough for any material one is likely to have. However, the width is hardly satisfactory. Ten inches will contain Department of Agriculture bulletins, but it will not take separates from the *Journal of Agricultural Research* or *U. S. Fish Commission Bulletins*, for instance. The former are 7 x 10¼, and the latter 7¾ x 11. It has been found practicable to have the company manufacturing a line of filing devices, build a vertical unit in which drawers have the height of invoice drawers and the width of letter file drawers—that is, 8¼ x 12⅛ inches. This apparently occasions small difficulty in putting the order through the factory, as only nominal charge for the change was made. However, if it is not practicable to secure this special size, the letter file may be used with complete satisfaction; and the invoice file may be used within the limitations mentioned. A cheaper but fairly satisfactory outfit for the storage of pamphlets may be secured by the use of sectional transfer cases of letter file size. These are commonly used by business houses to store correspondence that is no longer in current use and which may therefore be stored in an out-of-the-way location. Since these files are not commonly consulted, the drawers are not built to be used with the same ease and convenience as the regular line of filing appliances, and they should not be purchased for pamphlet files unless under necessity, and then only after inspection has satisfied the purchaser that they will be perfectly satisfactory for his purposes. Their most serious fault is in the lack of any device to suspend the drawer when it is drawn out, and the absence of a follower to adjust to a varying bulk of contents.

It is well to call attention to the further fact that all types of office devices of the nature described are now made in steel as well as in wood. While the possibilities have not been investigated, it is supposed that little difficulty would be encountered in securing such slight modifications as have been suggested. The steel cabinets have the advantage of being more nearly vermin proof than the wood cabinets are. Damage by mice should be practically eliminated by use of steel storage, and that by insects could be greatly reduced.

It is possible, therefore, to supply storage facilities for almost all laboratory property, with the exception of that preferably stored on shelves, by the use of commercial office devices. These devices need little or no modification from commercial standards to adapt them perfectly to laboratory uses. The elasticity of the system, as well as the excellence of the care it affords to laboratory property, is such that these devices are superior in general to the special furniture commonly sold for laboratory equipment.

AGRICULTURE OR BOTANY, WHICH?

By Vesta Holt,
Medford, Ore.

The tendency of recent years toward the practical has caused many to look askance at botany on the curricula of our high schools. Most of our progressive teachers have made the botany courses among the most practical, but our radical pedagogs have recalled the excessive nomenclature of the systematic botany of former days, and condemned botany as utterly useless. Others took up the cry and so, without trial, botany was in a fair way to be laid on the shelf alongside of astronomy.

Many schools substituted agriculture. Usually this was a slight modification of the eighth grade course, varying in value with the preparation and resourcefulness of the teacher. Such a course can hardly be popular. The students, as a rule, do not recall their previous work with a great deal of interest. Those who are vitally interested usually know nearly as much from their own experience and reading as is given in a high school course. We cannot give a college course for lack of time, equipment, and experimental farms. Also, for such a course, botanical principles are needed as a basis. Then, what are we going to do? Call our study agriculture and give our students practical botany? No, better yet call it by a new name and shape the course to fit local needs. We like to investigate new ground, especially if there is a connecting link with our previous experience—if there is a sufficient smack of familiarity to give us a little self-confidence.

Last spring we found in our high school three groups of students seeking a science elective. One group desired botany, the second wanted agriculture, while the third group were interested in neither. Our principal suggested agricultural botany as a solution. Those wanting botany were dubious, but willing

to try it. The agriculture group were well pleased, while it sounded both practical and scientific to the third, and they were content.

As the teacher of the course, I was considerably puzzled as to what it should be. Furthermore, I had only one day in which to determine, as class work began the next day after registration. Two things were to be considered—the interests of the students in electing such a course, and the local field for work. The chief industry of the community was fruit raising, particularly pomes. Warren's *Elements of Agriculture* was chosen as a text, but not used during the first six weeks. This time was devoted to rather an intensive study of different forms of plant life, giving especial attention to physiology, growth, and environment. It was the intention to make the latter part of the course a study of the agriculture—particularly horticulture—of the community. Hence the aim of this beginning was to emphasize those principles that would be essential to that following. This made it possible to limit the broad field to the time allotted.

The remainder of the course included such subjects as seed germination, irrigation (a very vital topic in the Rogue River Valley at the time), drainage, soils, fertilization, plant pathology, grafting, plant breeding, etc. The county pathologist and entomologist took much interest in the course, and their assistance was invaluable. They gave practical demonstrations of diseases and insect pests of local importance, including excursions over the valley, where the effects and methods of combating them were shown.

Recognizing the varying interests of the class, we arranged for special work to be taken up by individual groups. This included a soil survey with samples, collection of weeds, Mendel's law charts, grafting including diagrams, charts, and photographs, etc. Four periods a week were devoted to laboratory work and part of this work was done at this time.

The course was a success from every point of view. We did not turn out expert orchardists, nor did we expect to. However we did succeed in giving to each one the basic principles to build upon if he desired. In this community there are none who do not feel the horticultural interest, hence its especially local value. The plan this year is to enlarge upon the course and make it a regular subject on the curriculum. It is no longer an experiment.

THE MEASUREMENT OF HIGH SCHOOL MATHEMATICS.

By S. A. Courtis,

Supervisor of Educational Research, Detroit Public Schools.

When the Germans started to come through Belgium, the world expected the great forts along the border to hold out long enough to give the Allied forces a chance to rally to their defense. But the Germans had studied those fortresses; they knew the details of their construction and their strength. They had prepared themselves accordingly. Their big guns had been specially built for the express purpose of knocking the forts to pieces, and when the Germans were ready, concrete and steel crumbled to dust.

I have recalled to your mind this incident of the early history of the great war because I want to commend to your thoughtful consideration the subsequent behavior of the French. They, too, had forts along their borders, forts into whose construction they knew the utmost thought and care had gone. It would have been natural to feel that their forts were better, and that they could put up a better defense than the Belgians had done. However, they did nothing of the kind. They profited by the experience of the Belgians and changed their plans. By trench warfare they prevented the Germans from getting their big guns near enough to do at Verdun what they had previously done in Liege.

Some years ago war was declared in the educational world, war on the doctrine of formal discipline, and upon all subjects for whose presence in the curriculum formal discipline is given as a reason. The weapon of attack is the experiment and the educational test. The forty-two centimeter shell is the old theory of faculty psychology which the aggressors explode on all occasions with deadly effect. None of the old educational defenses can stand against it. At the present time, the enemy bids fair to carry all before them and to establish their "kultur" throughout the educational world.

When this war was first declared, the teachers of mathematics were all pacifists. The first attacks were directed against Greek and Latin, and many of you felt that you had no cause to intervene. You were more than half convinced by the enemy's arguments and thought that perhaps those dead languages deserved what they were getting. You withheld your assistance and the outposts have fallen. Greek has gone, Latin is going. Would you advise any young man to train himself to teach

Greek in a secondary school today? I know a university professor of Latin, the head of the department in fact, a mature man with three children, who has seen the handwriting on the wall, and is today preparing himself for work in another field. There are many former teachers of Latin who are teaching Latin no longer.

Today it is high school mathematics that is under fire. When Dr. Snedden in 1914 raised the question as to why girls in high schools or men going to follow law, medicine, journalism, or theology, should study algebra, his conclusions were welcomed by a few, but scornfully rejected by most teachers of secondary mathematics. However, the reception accorded Dr. Flexner's *A Modern School* has been of quite a different character. Evidently the leaven has been working during the three years between the publication of these two documents. Some of you are waking up to the fact that this is your war, that it is your professional work that is endangered, and that far from being an academic question to be discussed pro and con in the spare moments of conventions, the problem of determining the validity of the doctrine of formal discipline is a vital, dynamic problem, upon whose solution one way or the other depends the outcome both of your professional career and of the teaching of mathematics in the secondary schools of the United States.

And so I come today to discuss this question with you from the viewpoint of a yardstick man. The invitation of your Secretary mentions "combating the influence of the ultracritical antagonists of mathematics," referring specifically to Dr. Flexner's *A Modern School*. I have accepted that invitation, although not perhaps in the sense in which it was extended, and I am here. But if you are really alive to the situation you will first of all demand that I show my colors and make clear with which side I am going to fight.

I class myself as primarily a formal disciplinarian, born and bred. If I cannot truthfully say I imbibed the doctrine in the milk from my mother's breast, because I wasn't raised that way, I am at least sure that it was securely planted in me by my father's shingle. With my father's able assistance I managed to pull through four years of Latin and two of Greek, but I believe my Latin teacher was retired on a pension shortly after, and my Greek teacher went to an early grave. I am sure that in these subjects I can qualify under the most rigid specifications. I had a full measure of discipline of one kind, only it

was the wrong kind. I am frank to say, I could not see then, nor can I now, any beneficial disciplinary effects worth the time and effort expended, certainly none that could not have been obtained as well from more valuable and more interesting activities. Even such pleasure and culture as made themselves evident *came from reading the translations in the ponies* which my father found among his old schoolbooks in the garret. Never will I consciously aid in the subjection of adult, child, or beast, to training of that type.

In mathematics and science, however, the situation was entirely different. These were for me the profitable disciplines, and I have specialized in these two fields all my life. My seventeen years of teaching experience have all been gained in mathematics and science, and my present work is of the same general character. Now up to the time war on formal discipline was declared, I had always supposed I was transferring the general powers of observation, analysis, reasoning, etc., acquired by my study of science and mathematics, to all my work. I am of that opinion still although not so certain of it as I used to be. In other words, after mature and careful consideration of all the evidence presented by those who would have us think differently, I find nothing that has compelled me to surrender my early convictions. In spite of the courage it takes to say it, when I realize that I am running counter to the conclusions of such men as Dewey, Moore, and Spearman, I still believe that the study of mathematics may have a peculiar and distinctive function of a disciplinary character which would make it undesirable to substitute any other type of training for it.

On the other hand, even above my love for mathematics, I prize the truth. I rate myself a scientist and an experimentalist. In spite of my bias of personal prejudice in favor of formal discipline, I shall instantly abandon my position and strike my colors as soon as I find convincing evidence that is clearly against me. If, therefore, you are not equally willing to put your faith to the test, do not welcome me into your camp.

I have still another interest in this question, another viewpoint from which to judge. My oldest boy is in the seventh grade. In another year, or in two at most, I shall be compelled to take sides. That is, I shall probably be called upon to either wield a shingle as my father did before me, or to join the enemy by encouraging sedition and insurrection at home, if not by

actually lending my support to the movement by other fathers and mothers to have mathematics eliminated from the high school course.

Therefore, I want to go over this matter with you carefully this morning, to define our problem as clearly as may be, and to discuss the steps that must be taken "to combat the influence of the ultracritical antagonists of mathematics."

The greatest difficulty that confronts us at the outset lies in the vagueness of our past thinking and writing. We have all seen so many instances of transfer in our own lives and in the lives of our pupils that we have been content to describe the phenomenon in the most general terms. "There, that is it," we say, pointing out a particular instance to our fellow teacher, and he, out of his common experience, understands what we mean. But these psychologists get us to commit ourselves to words and then pull our words to pieces because we were not careful to say precisely what we meant. It may even be that when we have succeeded in formulating a scientific statement of what we really mean by transfer, it will be acceptable to our critics also. One thing is certain; now they often talk about things we do not mean at all. For instance, Professor Dewey, in discussing transfer and formal discipline, says, "in the literal sense any transfer is miraculous and impossible." At another place he says, "Going to the root of the matter, the fundamental fallacy of the theory is its dualism; that is to say, its separation of activities and capacities from subject matter. There is no such thing as an ability to see, or hear, or remember in general; there is only the ability to see, or hear, or remember something. To talk about training a power, mental or physical, in general, apart from the subject matter involved in its exercise, is nonsense." Let us hasten to agree with Professor Dewey. We also believe that if a person sees, he sees something, that if he remembers, he must remember something. This should make it clear that if we speak of training the power of observation in general, we must do so in words which cannot by any possibility imply any supernatural power to observe when there is nothing to be observed.

Again, Professor Moore says[1]: "The universe of fact is no snug-fitting box with interchangeable parts which we can put together and take apart again. It is infinitely complex, and he

[1] *School & Society*, Vol. VI, No. 148.

who is being trained to operate any part of it must be familiar with the characteristics of his particular field of fact and the process of manipulation which belongs to it."

Let us hasten to agree with Professor Moore, also. We do not even believe that learning Theorem I in a geometry text-book will automatically enable the student without further study to state Theorem II. Much less do we believe that the acquisition of skill in solving a problem in algebra will function as skill in playing a piano. We all recognize, I am sure, that in every act in life there are specific elements, and that each of these elements must be acquired by specific training. We do not expect the mechanic who has received only training to adjust a Packard engine to be able to adjust the engine of a Stanley steamer without additional training. We are even ready to admit that if a bank clerk had received such a long training in counting money of a certain kind in a small country bank that his counting had become well-nigh automatic, he would be almost certain to make mistakes when in a city bank he attempted to break up the old specific habits and substitute new ones for them.

None of these things are what we mean by transfer. They but serve to show how careless in our past statements we must have been, how careful we must be in the future. Clear definition of aims is not an easy thing to accomplish. We shall probably not succeed at any one time, a nd we shall want to modify our statements as our understanding grows. However, as long as we have faith that we are attempting to describe real phenomena, the mere fact that our analysis of the situation is faulty, our choice of words inadequate, does not prove that the thing itself does not exist. We must try and try again until we make our meaning clear. No failure should weaken our determination.

My understanding of the meaning of general training, the kind that transfers, is this. The activities of a new-born babe are determined by instinctive response to stimuli. As experiences multiply, however, other factors begin to operate. Feelings are aroused, reflection sets in, relations and meanings crystallize. The individual becomes conscious of his growth in power to profit by experience. He not only comes to have a larger and larger stock of specific knowledges and skills, but he comes to have also greater and greater power to select with precision from this stock of knowledges and skills just those of most use

in a given situation, and he has greater assurance and skill in their manipulation.

It is probably this sense of conscious power to master the new situation in spite of any possibility of difficulties caused by the necessity to master the new specific elements in it, that has led to the term, "general power." General power consists of organized generalizations of past experience which roughly fit the new situation except for the adjustments made necessary by the new specific elements. It is not denied by anyone that observation, attention, memory, etc., are types of activities found in all situations into which consciousness enters. The theory of formal discipline assumes that, entirely aside from the specific character of certain elements of these activities, there are general methods of observing, remembering, etc., which it is advantageous to employ. The person who has conscious control over the general methods of efficiently carrying on any one of these types of activities has general power. I suggest that we define general training as that training which, while dealing with the acquisition of specific skills in a limited field, so directs the attention of the learner to the general details of the most efficient method by which success may be achieved that the individual being trained acquires not only specific skill, but a general philosophy of behavior applicable at once in all other situations of the same general type, upon the acquisition of any new specific skills that may be essential.

So far I have been speaking in general terms. Let me make the discussion more concrete. If a teacher of algebra uses the situations which arise to teach a student to classify and to generalize, if he brings to the consciousness of the student a knowledge of the laws and difficulties of generalization and gives him power to use the same in algebraic situations, the student will not only learn to factor well as soon as the specific elements of factoring are under control, but he will be able to transfer this power to, let us say, making a summary of a chapter in history just as soon as he masters the specific elements of such work.

Professor Moore has said: "Let the memory alone. Take no memory training lessons, give up forever the notion that a memory ever existed outside the world of fancy which could remember all things equally well, let memory alone, and give your whole attention to comprehending what you want to remember. That is all that you or anyone else can do. This

you see requires us to shift our attention wholly from mind to the content."

This seems to me a faulty statement. In effect it says: "Pay no attention to the agent, concentrate your attention wholly on the content. Since your memory for theorems in geometry will differ from your memory for men in history, no benefit from the work you do in geometry can transfer to your work in history." This is probably absolutely true in the sense that no amount of training in remembering geometrical material is likely to affect your native memory for men in history, but it ignores that most important element, the person doing the remembering. He is a common element in both situations. If he learns in geometry the function that memory plays in successful work, he will see to it that he remembers in history, even if he had a good memory in geometry and a poor memory for names. This is exactly the importance of general training. The school cannot possibly hope to give training in *all* the specific skills which the individual must acquire. It must, however, teach the individual how to succeed in any situation that may arise, and if it so handles typical situations in school that the individual is graduated with a knowledge of the functions and laws of operation of the ten or twelve great fundamental activities of life, he may be counted on to take care of himself. In fact, so thoroughly convinced am I that general training is not only possible but absolutely essential, that I venture to prophesy that in the future the curriculum of the elementary school at least will be organized on the basis of activities and not of subject matter.[2]

I have recently seen an institute program on which Professor Whipple was scheduled to lecture on the fascinating subject, "How to Attend and Never Forget." Professor Whipple is, in my judgment, giving those three thousand teachers general memory training, because to be of value his recommendations must cover every type of specific memory there may be. As it will be quite impossible for him to mention them all, he must resort to generalizations and laws. We can be reasonably sure that in forty-five minutes not much of his lecture will take. The exposure is too short. But if Professor Whipple could give that same training to those same people in groups of thirty-five, using as a medium of transmission and experience

[2] I am indebted to Professor Thompson of the University of Colorado for the suggestions upon which this prophecy is based.

a year's work in geometry, I am sure the transfer value of the course would be very great.

So far I have been following the bad example of our adversaries and making dogmatic statements of what I *believe* to be true, as if it were. Let me hasten to admit that I have no scientific evidence to support a single one of the many assertions I have made. Such evidence as I have, and I have plenty of it, is derived from personal experience and from observations of striking cases in the lives of others. Such evidence has no scientific validity and it is useless to present it. I am not discouraged, however, as my five years of effort to secure valid data have yielded returns which not only give promise that critical experimentation does not lie very far in the future, but also indicate points of weakness in the evidence of our opponents. We must be perfectly willing to abide by the results of valid tests, but under no circumstances should we accept returns at their face value; that is, without a careful study of their nature and reliability. No evidence can be accepted as valid until:

1. The criteria by which the nature of the abilities measured by the test were determined, are satisfactory.

2. The reliability of the tests used have been scientifically demonstrated.

3. Development of general ability in the specific field has been proved to exist before the test for transfer is made.

I wish to discuss each of these points.

Some years ago I constructed a test which I thought was a measure of ability to reason in arithmetic. Later I found that success in the test was dependent more upon reading ability than upon ability to reason. Would a study of the transfer of ability to reason from geometry to arithmetic, based upon the use of that test, lead to valid conclusions? Most certainly not. It was precisely such lack of transfer that led to the discovery of the real nature of the test. Now read through the various experiments that have been conducted to determine whether or not transfer takes place, and look for a discussion of the criteria by which it was determined that the tests used measured the abilities they were really supposed to measure. The science of test construction is in its infancy, and little has been done in the way of establishing criteria. Careful men like Professor Thorndike dodge the issue because no wholly satisfactory statement is possible at this time. For instance, Professor Thorndike says of his reading test, "Call achievement

in paragraph reading that thing much of which enables an individual to respond correctly to a difficult paragraph and questions about a paragraph." This seems to me to be of the nature of educational camouflage. What he has done is to make a test in which the response on analysis proves to be influenced by such abilities among others as ability to read, reason, write, and spell. He is unable at this time to state what part each of these separate elements plays in determining the response, so he begs the question by saying, "I will call ability to do this complex thing reading ability." Reading ability *is* the chief factor in a successful completion of the test, but some children who fail in the test would be judged able to read by other standards.

The reason for our present uncertainty in regard to what tests measure lies in our lack of knowledge of the laws of combination of mental elements. If we put two pounds of sand into a one-pound box, the whole will weigh three pounds, at least within the limits of error of our apparatus. But if we add to any mental situation a single new factor, the result is not at all the sum of the component elements. For instance, all of you know how to walk, and walking is a complex and relatively stable habit. If now I were to dwell at length upon the need of grace in walking, and were to state that we had present in this audience a person renowned for his grace in walking, and if I were then to suddenly call upon *you* to walk across this platform that the audience might profit by your example, very many of you would suddenly become self-conscious. Your subsequent failure to walk naturally would really be a measure of your lack of control when self-conscious, not of your ability to walk.

I am sure you have all had the experience of setting what you thought was an easy examination, and of having your class "go all to pieces" on it. What happened was not the sudden evaporation of all the results of your teaching, but the transformation of what was apparently an examination in geometry into a situation which was really a test of self-control because of the introduction of some small factor judged to be of no importance. It is always extremely pertinent to inquire whether or not a given test really measures the ability it seems to measure before accepting conclusions based upon its use.

The need for a study of the reliability of a test is equally great. The reliability of a single trial of almost all our present mental and educational tests is low. Take my own arithmetic

tests, for example. The general coefficient of reliability for the individual accuracy scores in addition was .5 for one group of children I measured. In division, the reliability was 0. This does not mean at all that the tests are valueless. The class score of a group of twenty children is a reliable measure of their general accuracy of work, but the scores of an individual indicate merely what he did in that test. In the next one his accuracy may vary from 100 per cent to 0, or vice versa, depending on the play of many factors. To determine the ability of an individual reliably, several tests under varying conditions are necessary before a safe inference is possible.

Now my addition test is a test of a very simple ability, relatively, and it was constructed after several years of experimental work. It is one of the most reliable tests of its type. Now, if the correlations between two trials of a geometry test is .4, and between two trials of a memory test is .5, and between the geometry and memory tests .2, how far is the apparent lack of correlation really caused by the unreliability of the tests themselves?

I wish there were time to discuss in detail with you some of the evidence that has been cited against transfer. I shall content myself with a single illustration, Dr. Rugg's careful experiment in measuring the transfer effect of a college course in descriptive geometry. You will remember that there were two groups. The control group did not take the course in geometry, the training group did. Both groups were measured at the beginning and at the end of the training period. Dr. Rugg summarizes part of the results in the statement:

"In attempts 67.8 per cent of the training group and 42.5 per cent of the control group gain in 60 per cent or more of the tests taken."

Professor Moore comments on this statement as follows:

"That is, 42½ folks out of every hundred who did not have the training took the tests as successfully as 68 out of every hundred who did have it. That is, the course seems to have been of some positive assistance in preparing only 25½ out of each hundred to take the test; to 32 out of every hundred who took it it was no help; and 42½ out of every hundred who took it got on just as well without it as with it, that is, so far as attempts went."

This raises some interesting questions. If 42½ folks out of every hundred who did not have the training took the tests as

successfully as 68 out of every hundred who did, whence came this increased power? The changes in score may all have represented merely the unreliability of the tests themselves. On the other hand, these results might represent transfer from other courses. The students in the control group were not idle during the fifteen weeks. Yet one would hardly expect training in, say, English, to transfer to tests in the "mental manipulation of spatial elements." Perhaps the tests did not measure what they were supposed to measure. Dr. Rugg's statement on this point is over and over again: "Test 1 and 2 *are regarded* as giving measures of.....; Test 3 *is believed* to be a measure of .....; Tests 4 and 5 *are regarded* as measures of .....," etc., etc. But Dr. Rugg is careful to give the coefficients of correlation between these tests. For the initial trials of Tests 4 and 5, the correlation coefficients are .26 and .42, for the training and control groups respectively; for the final tests, .42 and .48. These figures speak for themselves.

Then again, the 32 individuals in the training group who made no gain, provoke all sort of desires for further information. Was their apparent lack of gain a result of merely chance variation, or was it due to the fact that they had nothing to transfer? Perhaps they spent fifteen weeks in work with Dr. Rugg and got nothing out of it as compared with the gains of the rest of the class. Now, Dr. Rugg is an excellent teacher, as I have reason to know, and if the University of Illinois furnished him with such poor material that in spite of his ability a third of the class were incapable of profiting by his efforts, was it fair to use these individuals as the subjects of a transfer experiment? I have always been told that it is essential to catch a hare before you try to skin it. It would seem wise, therefore, to make sure by appropriate tests that there was something to be transferred before attempting to measure the amount of the transfer. Perhaps some of the control group were morons also, or perhaps the other teachers were not as efficient as Dr. Rugg. At least it is clear that there were very many factors which might have determined the results. In the absence of exact knowledge one guess is as good as another.

I might review in similar fashion the thirty-odd other experiments dealing with the question of transfer and show that all of them are open to criticism on one point or another. I might select the work of Scholckow and Judd as the one significant experiment of the group. But I shall do none of these things.

Instead I shall content myself with two quotations from Professor Thorndike. In his *Educational Psychology*[3] he says: "No one can doubt that *all* of the ordinary forms of home and school training have some influence upon mental traits in addition to the specific changes which they make in the particular function the improvement of which is their direct object. On the other hand, no careful observer would assert that the influence upon other mental traits is comparable in amount to that upon the direct object of training ..... The real question is not, 'Does improvement of one function alter others, but to what extent, and how, does it?' " Again he writes,[4] "A survey of experimental results is now needed perhaps as much to prevent the opposite superstition; for, apparently, some *careless thinkers* have rushed from the belief in totally general training to the belief that training is totally specialized."

The truth of the matter is that we are but just learning how to attack the problem experimentally and have not yet reached the point where conclusive results may be obtained. In our present experimental evidence there are plenty of suggestions which afford a basis for adopting the doctrine of formal discipline as a working hypothesis, provided we do not stop at this point and consider the adoption proof. Nevertheless, it seems to me perfectly evident that if the training in mathematics which we give is to have real transfer value it must be so organized and administered that it will produce transferable results. For nothing is more certain than that it is easily possible to *so* teach algebra and geometry that the teaching results in nothing more at best than specific skills. I, for one, am ready to agree with Professor David E. Smith that the presence of algebra and geometry in the curriculum cannot be justified wholly on the basis of their content or cultural values.

A point raised by Dr. Flexner and others needs discussion here. They suggest that equal general training may be given in connection with other work of higher content value. Some of us think differently. This difference of opinion should be settled on the basis of objective evidence. In my judgment, the distinctive function of mathematics in the curriculum is to make clear to immature minds the general method by which problems are solved, to teach them, as Professor Dewey says, "how knowledge arises." In terms of the formal discipline theory

[3]Vol. II, page 358.
[4]Vol. II, *Educational Psychology*, p. 364.

their function is to give the student general training in the theory and practice of collecting, analyzing, classifying, and generalizing data, of formulating plans and executing them, and of evaluating the result achieved in terms of the result desired. To this end, algebra and geometry must be so taught as to afford opportunities for both inductive and deductive reasoning.

The reasons why similar training cannot be given as efficiently in other subjects are three:

1. In mathematics the subject matter is absolutely devoid of emotional appeal, so that attention is easily directed and held upon the essential elements of method.

2. The mathematical environment is the only one under man's absolute control, so that the difficulty of the problems presented may be perfectly adjusted from simple to complex to suit the progress of the learners. In mathematics alone is man an omnipotent creator. He speaks the word, and it is so. Parallel lines may be made to diverge, to meet at infinity, or to converge at will. Mathematics is the only "science of necessary conclusion," the only environment in which a man can check his reasoning processes against certain truth.

3. Mathematical apparatus is the cheapest on the market, requires less space, and affords a wider range of projects than any other. Paper, a ruler, a pencil, a compass, and a protractor give entrance to a universe full of concrete problems ranging in difficulty from the simplest to the most difficult yet conceived by the mind of man.

For the purpose of practical training in the development of general powers, we believe algebra and geometry are without equals. Who will produce the objective evidence with which to convince the world?

I have dwelt at length on this phase of the warfare, because I note a growing tendency on the part of mathematics teachers to be afraid to confess that they really believe in the doctrine of formal discipline. I hope to make it plain that as a working hypothesis it is still tenable, and to offset so far as I am able some of the recent articles that have been written. I think we have little to fear from such attacks, if both in our teaching and in our testing we prove that we are working consistently and efficiently, and are making progress. But there is another sort of attack that is much more dangerous because the charges made are easily proved.

For instance, Dr. Flexner says: "The education we are criti-

cizing is overwhelmingly formal and traditional. Most children in the elementary and high schools struggle painfully and ineffectually to bring the subject matter of their studies within a world that is real and genuine for them. The best of them succeed fitfully. Most of them never succeed at all."

These are the real reasons why attacks on the presence of algebra and geometry in their present form are supported by public sentiment—*their formality and their failure.* The successful school may advance any theory it pleases to explain its success, but it must be successful, and its students must be convinced that they are succeeding during the period in which they are taught. Dr. Flexner voices this demand most clearly. If we piece together various sentences describing the basic principles upon which he thinks the curriculum of the modern school should be determined, we get this statement:

"A man educated in the modern sense will obtain his education form studies that serve real purposes. Its content, spirit, and aim will be realistic and genuine. The man will be trained to know, to care about, and to understand the world he lives in, both the physical world and the social world. A firm grasp of the physical world means the capacity to note and to interpret phenomena; a firm grasp of the social world means a comprehension of, and a sympathy with, current industry, current science, and current politics. The object in view would be to give the children the knowledge they need, and to develop in them the power to handle themselves in our own world. If a subject serves a purpose, it is eligible to the curriculum, otherwise not. The burden of proof woeuld be on the subject, not on those who stand ready to eliminate it. Modern education will include nothing simply because tradition recommends it or because its inutility has not been conclusively established. It proceeds in precisely the opposite way: *it includes nothing for which an affirmative case cannot now be made out.*"

I want you to note particularly that Dr. Flexner emphasizes the formality and failure of mathematics courses as taught at present. He refers to the doctrine of formal discipline more than once, but only to emphasize that it is "an unproved assumption" and, therefore, not a valid reason for including a subject in the curriculum. His real indictment of the formality of present mathematics teaching is as follows:

"The subject of mathematics offers peculiar difficulty. Perhaps nowhere else is waste through failure so great. More-

over, even when a certain degree of success is attained, it happens often that it is quite unintelligent; children mechanically carry out certain operations in algebra, guided by arbitrary signs and models; or they learn memoriter a series of propositions in geometry. The hollowness of both performances—and most children do not accomplish even so much—is evident the moment a mathematical problem takes a slightly unfamiliar term. The child's helplessness exhibits a striking lack of both mechanical knowledge and 'mental discipline.' It cannot be that this training through failure is really valuable. Finally, a point might even be made on the ground that algebra and geometry as traditionally taught are mainly deductive exercises, whereas practical living involves the constant interplay of observation, induction, and deduction. The artificiality of conventional mathematics, therefore, raises a suspicion as to its value—even were the subjects mastered.

It is for those who believe in it to demonstrate how much good it does most children to make a failure in algebra and geometry. Is the elaborate study of mathematical and spatial relations through algebra and geometry a valid undertaking for its own sake? If so, neither the disinclination of the child nor the difficulty of the achievement is a reason for abandoning it. Disinclination and difficulty in that case simply put a problem up to the teachers of the subject; it is for them to find ways of triumphing over both. If, however, this study does not serve a legitimate and genuine purpose, then the mathematical curriculum must undergo a radical reorganization for the purpose of treating algebra and geometry from the standpoint of the other subjects which they serve. They would be taught in such form, in such amounts, and at such times as the other subjects required. Thus geometry would be decreased in amount by something like two-thirds or three-fourths,[5] and the form of the remaining fourth would be considerably modified."

His statement of the failure of mathematics teaching is equally strong: "It is perhaps worth while stopping long enough to show by figures the extent to which our current teaching fails. Complete statistics which would tell us how many of all the pupils who study algebra and geometry fail to master them do not exist. But we do know that a large percentage of the better students of these subjects try the college

[5]All the facts of geometry that a skilled mechanic or an engineer would ever need could be taught in a few lessons. All the rest is either obvious or is commercially and technically useless.—D. E. Smith, *Teaching of Geometry* (New York, 1911), p. 7.

entrance examinations, and that for these examinations many receive special drill in addition to the regular teaching. Now in the examinations held by the College Entrance Board in 1915 ..... 69.7 per cent of those examined in algebra from quadratics on failed to make as much as 60 per cent; 42.4 per cent failed to make 60 per cent in plane geometry. What would the record be if all who studied these subjects were thus examined by an impartial, outside body? Probably some of those who fail do not do themselves justice; but as many—perhaps more—of the few who reach the really low mark of 60 per cent do so by means of devices that represent stultification rather than intelligence. For nothing is commoner in the teaching of ..... formal mathematics than drilling in arbitrary signs by means of which pupils determine mechanically what they should do without intelligent insight into what they are doing. It is therefore useless to inquire whether a knowledge of ..... mathematics is valuable, because pupils do not get it; and it is equally beside the mark to ask whether the effort to obtain this knowledge is a valuable discipline, since failure is so widespread that the only habits acquired through failing to learn ..... algebra are habits of slipshod work, of guessing, and of mechanical application of formulae, not themselves understood."

Are his statements valid? The judgment of the world is apparently that they are. If you don't believe it, you can easily test the matter for yourself. Compare your own percentages of failures and your own methods of teaching with those of some of the successful courses in a modern technical high school. This is not a question of formal discipline. There must be something to transfer before transfer can take place. This is a case of pedagogical inertia, paralysis, and stagnation We have persisted in the use of outworn methods and taken no account of the changing needs of the times.

I wonder what you will do about it? In this connection the article on the "Status of Mathematics in the Secondary School," signed by a committee of six mathematics teachers in and around Chicago, is very interesting reading.[6] They take seven pages of space to present the opinions of fifty-five adults as to the value of their mathematics training. In other words, in these days when men are realizing as never before that human judgment is unreliable and needs the check of objective measure-

[6] *School & Society*, Vol. VI, No. 151.

ment, the best these mathematics teachers can do is to appeal to the opinions of men who went to school when the doctrine of formal discipline was as religiously accepted as was the doctrine of the literal inspiration of the Bible. It is interesting to note that of the fifty-five opinions, ten found the courses of practical worth, three others gave pleasure as the reason for its value. This, of course, leaves but forty-two to pass upon the transfer value. Of these, six, or 14 per cent, gave negative answers. The committee concludes: "These testimonies and the results of these investigations make it evident that algebra and geometry are not so much rubbish to be thrown out at the back door as quickly as possible, as some would have us think. The number who object to the requiring of mathematics in our high schools is relative a small minority, which in its effort to be heard sometimes makes a noise all out of proportion to its numbers. The professional, business, and industrial worlds, at least, demand for the present, and will demand for years to come, that algebra and geometry be retained as required studies in the secondary schools of our country; and this notwithstanding the efforts of educational theorists and would-be reformers to the contrary. Would it not be time and effort better spent if the destructionists were to aim at the perfecting of the subject matter, and the improvement of its teaching?"

Do you think that sort of a reply will have much weight with either the general public or the men who are devoting their lives to the improvement of education and to the formulation of an adequate educational philosophy? How much more reasonable is Dr. Flexner's statement, "Without considering any point settled, it is clear that a modern school which wiped the slate of mathematics and then subsequently wrote upon it only what was found to serve the real needs of quantitative thought and action, might evolve a curriculum in mathematics that we should not recognize."

Probably this is the place to comment on the way Dr. Flexner's *A Modern School* has been received. The newspaper reporters have interpreted it to the public as an attack on existing institutions. Certain schoolmen, also, have been greatly excited by these reports and seem unable to understand what Dr. Flexner has written. As I read his statements I find nothing but the desire to bring about exactly what the Committee of Mathematics Teachers demanded, the perfecting of the

subject matter and the improvement of its teaching. Consider this paragraph, for instance:

"In education, as in other realms, the inquiring spirit will be the productive spirit. There is an important though not very extensive body of educational literature of philosophical and inspirational character; but there is little of scientific quality. The scientific spirit is just beginning to creep into elementary and secondary schools; and progress is slow, because the conditions are unfavorable. The modern school should be a laboratory from which would issue scientific studies of all kinds of educational problems—a laboratory, first of all, which would test and evaluate critically the fundamental propositions on which it is itself based, and the results as they are obtained."

In other words, a modern school that lives up to these ideals would not hesitate to try a course on any subject under heaven and by any method, provided a reason for such action could be advanced sufficiently plausible to make the trial worth while; provided, further, that the nature of the course and method gave promise that scientifically valid evidence would be secured as to whether or not the objectives of the course were being attained. For instance, both algebra and geometry are now actually being taught in the experimental school which has been established in New York City by the General Education Board. You know very well that if I say, as I want to say, that the only action for mathematics teachers to take is to face the situation squarely, criticize both subject matter and aims in the light of present needs and present knowledge, formulate anew the distinctive functions of the mathematical training, and then devise both methods that will produce the desired results and tests which will prove the fact, you will at once counter with the charge that you are not free; that you are bound both by convention and by college entrance requirements. This is precisely why the modern school should receive the enthusiastic support of all mathematics teachers who really believe in the value of training that they give. The modern school is to be bound by no traditions, is free from all requirements. "The education of the particular pupils who attend the modern school," says Dr. Flexner, "might prove to be the least of the services rendered by the school. More important would perhaps be its influence in setting up positive as against dogmatic educational standards."

This brings me to the real subject of my paper, to which

all that has gone before is but the introduction. Positive educational standards can be set up in but one way, not by faith, not by hope, not even by the charity of biased or unbiased opinion, but by measurement, and by measurement alone, can educational goals be established. If the goals of mathematics training are to be transfer values, then tests for the measurement of such values must be devised, and your methods must be carefully studied and improved until they have been made as efficient as they can be. If the doctrine of formal discipline is wrong and the products of mathematics teaching are to be only certain specific knowledges and skills, then the amounts of such knowledges and skills to be developed must also be determined on the basis of exact measurement.

The program I recommend to you, therefore, has three main items.

1. Formulate as definitely and objectively as possible the aims of your teaching.

2. Study your method of teaching and make sure it is the one best adapted to bring about the desired results.

3. Devise standard tests which measure the product desired, and find out whether you are or are not securing these products as well as other teachers.

This is likely to take some time, and there is need for immediate action. If I were teaching a class in either algebra or geometry this year, I should give at the opening of the course, and repeat at its close, the Kansas Silent Reading Test and the Trabue Language Scale. Both of these tests measure roughly general ability. If possible, I should also test, in similar fashion, two other high school classes composed of pupils not taking mathematics. I could then compare the scores and growths made by my classes with those made by the other classes. The reason for the use of these particular tests is that they are easily given, can be scored by the students, and can be secured in duplicate forms of equal difficulty. I should use Form I of the Kansas Test for the first trial, making the time three minutes, and Form III for the second. I should use Scale B for the first trial of Trabue, and Scale C for the second.

If I were teaching algebra, I would give the Rugg Algebra Tests at the beginning and end of the semester and compare my results with those of other teachers. For geometry I would get in touch with some of the various committees on tests that are at work and give similar tests in geometry.

For both algebra and geometry, I should also give the Thorndike Reading Test, Scale Alpha 2, at the beginning of the year. This would tell me which children could read and which could not, and I could then govern myself accordingly in helping my students. In similar fashion, if I were teaching algebra I would give at the beginning the Courtis Arithmetic Tests —for the fundamental operations, Test 7, Series A. This would tell me which children had command of the simple arithmetical skills and which did not, and I could adjust their work accordingly.

I should also compare the number of children dropping my subject and the number of failures I gave with similar data from other courses in the high school. All this would take a total of six or eight class periods and quite a number of hours of work outside of class, but when I got through I would have some real information about my work and I would know how to take the next step intelligently.

My friends, the enemy, which is no real enemy at all, but the best friend we have ever had, is at the gates. The outer defenses have fallen. Investigations are about to be made and, if necessary, changes. Are those investigations and those changes going to be made by persons now in charge of mathematics teaching and sympathetic with its highest aims, or by rank outsiders? The call to arms is sounding. The appeal is for your cooperation. What is to be your response?

NATURE STUDY SERIES.

An important contribution to the pedagogy of the field of science is just announced by the University of Chicago Press in a series of volumes to be known as *The University of Chicago Nature Study Series* and to be edited by Elliot R. Downing, Associate Professor of Natural Science in the School of Education at that institution. It has been a generation since an attempt was made to reorganize the methods of science teaching, and the books proposed are expected to be a distinct contribution to the development which is now in progress. The plan is to be inaugurated by a *Source Book in Biological Nature Study*, with a *Laboratory and Field Guide in Biological Nature Study*, and two notebooks—one for the elementary grades and another for the intermediate grades, all of which are being prepared by Professor Downing.

The purpose of the series is to fill the gap which now exists in the scientific education given by elementary and secondary schools. Science has long been taught in both types of school, but instruction has been of a haphazard character and is in need of reorganization. The School of Education of the University of Chicago, in the effort that it is making to improve grade and high school teaching in all departments, has found as a result of its investigations that the present methods of science teaching need a thorough overhauling in the interests of the child and of science itself.

RECENT DEVELOPMENTS IN THE FIXATION OF ATMOSPHERIC NITROGEN.

By George W. Sears,

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The fixation of atmospheric nitrogen is rapidly becoming one of the world's most important industries. Professor Stieglitz, in his address before the Boston meeting of the American Chemical Society last fall, said, "The fixation of nitrogen plants in Germany has unquestionably saved her thus far both from a military collapse and from starvation." Nitrogen compounds not only form the basis of all explosives, but also are among the most important of plant foods. The importance of fixed nitrogen at the present time is therefore evident.

Until a comparatively few years ago, practically the only sources of fixed nitrogen were the deposits of Chile saltpeter and ammonia and ammonium compounds obtained from the destructive distillation of coal. Though the Chilean deposits are enormous they are not unlimited. At the normal increase in consumption it has been estimated that the supply would last approximately fifty years. Until the beginning of the present war the amount of ammonia obtained as a by-product in coal distillation was comparatively very small. It has been estimated that less than one-tenth of the bituminous coal in this country is coked in by-product ovens. In Germany all of the coke produced is made in plants fitted for the recovery of by-products, including ammonia.

The past two years in the United States have seen a very great increase both in the number of by-product coke ovens and in the amount of ammonia produced in this way. More than fifty million dollars' worth of by-product ovens have been erected during the past year, and the annual output of ammonia produced in this way has increased to about 115,000 tons. If there were a general use of coke instead of coal throughout the country the annual output of ammonia obtained as a by-product in its production would approximate 1,000,000 tons. The needs of the present war, however, could not wait for the carrying out of such a program. On the contrary, atmospheric nitrogen is being fixed by the old processes and by processes which differ from the old only in minor improvements, while new processes are rapidly being developed.

For the manufacture of explosives HNO_3 is demanded in large quantities, and as a fertilizer ammonia is of prime importance. At the opening of the war four general fixation methods

were in use: The arc processes having HNO_3 as their immediate product, the Serpek process manufacturing AlN which is readily converted into ammonia, the cyanamide process manufacturing $CaCN_2$, which may be used as such or converted into ammonia, and the Haber process having ammonia as its immediate product. At the opening of the war this last process had just been placed upon a commercial basis, and up to the present time is used only in Germany.

Within the last year two other processes have been developed in the United States. One is a synthetic ammonia process devised by the General Chemical Company, for the carrying out of which they had begun a plant but stopped on account of the high cost of material. The process, however, was offered to the Government, and a plant is now being erected at Muscle Shoals, Va., for its use. The other process was devised by Professor Bucher of Brown University and is based on the manufacture of NaCN. The patent rights belong to the Nitrogen Products Company. It is not yet out of the experimental stage but, according to those who have investigated it, there is great probability that it will develop into the cheapest and most satisfactory process yet known. It was also offered to the Government and will be subject to further investigation by Government experts.

We are all more or less familiar with the arc processes, the principle of which depends on the direct union of oxygen and nitrogen to form nitric oxide under the influence of a powerful electric arc. The nitric oxide unites with more oxygen to form nitrogen peroxide, which is dissolved in water to form nitric acid or in alkali to form nitrates or nitrites. They possess the great advantages that the raw material, air, is free and always at hand, that only a small amount of labor is involved, and that nitric acid, the compound necessary in the manufacture of explosives, is the direct product. They depend, however, on cheap power, a thing which hardly exists outside of Norway, where water power is abundant. They also possess the disadvantage that the product HNO_3 is a very difficult substance to ship.

Nitrogen fixation by this process depends on the reversible reaction:

$$N_2+O_2 \rightleftharpoons 2NO-43{,}200 \text{ cal.}$$

Heat is therefore required to drive the reaction in the direction of the formation of NO. It has been found that at 2700° A.

less than 2 per cent NO is formed. The speed of the reaction at this temperature is very high. Therefore, in order to obtain appreciable quantities of NO, the resulting gas mixture must be cooled as quickly as possible. Sufficiently high temperatures can be obtained in the electric arc. By its application, along with devices for very rapid cooling, it has been possible to obtain as high as 2 per cent of the air in the form of NO.

Among the later improvements perhaps the most notable is that of the Birkland-Eyde, the oldest of the arc furnaces. The ordinary furnace of this type consists of water-cooled copper electrodes, the points of which come close together. In this way an easily movable and flexible current is established. It is arranged in a highly magnetic field which draws the arc out perpendicular to the lines of force until the resistance becomes so great that it starts back at the points of the electrodes. Alternating current is used so that the arc has the appearance of a circular flame a few centimeters thick and about three meters in diameter. In the new arrangement the air is forced in across the flame instead of in the direction of the arc as formerly. A current of cooling air is directed into the furnace just above the arc. This has proved very effective in cooling the reaction product. The arc processes, though not feasible for installation in the United States because of the large quantity of power necessary, are of vast importance in Norway where cheap water power is available. So far nitrogen has been fixed more cheaply by the arc processes than by any other method.

Of the processes having for their object the production of ammonia, the Haber process has received by far the greatest recognition, and at the present time is undoubtedly the most important. It consists in the direct synthesis of ammonia from its elements. The reaction is as follows:

$$N_2+3H_2 \rightleftharpoons 2NH_3+23{,}780 \text{ cal.}$$

Since the reaction is exothermic any rise in temperature must decrease the concentration of ammonia at equilibrium, therefore the temperature must be kept as low as possible. On the other hand, the velocity of reaction will decrease with decreasing temperature. A catalytic agent, however, is used to increase the reaction velocity. According to the equation the volume decreases with the formation of ammonia so that an increase in pressure tends to drive the reaction toward the formation of ammonia. The process then consists in working in the presence of a catalytic agent at temperatures as low as possible

and at pressures as high as possible. The temperature at which it is possible to work with sufficient speed depends entirely on the catalytic agent. A good many metals were found that would catalyze the reaction. Osmium, the most efficient, does not occur in sufficient quantities to make it practical. Uranium and tungsten were used in the early stages of the process. Finely divided iron is said to be used at the present time. The temperature of the reaction chamber is kept at 700° which is a very convenient temperature since steel may be used even with the high pressures necessary. The amount of ammonia formed under these conditions is probably not greater than four per cent of the mixture. It is necessary, therefore, to separate the ammonia and return the remaining nitrogen and hydrogen to the reaction chamber. The process in brief consists in working in a closed system composed of a reaction chamber in which the gas mixture comes in contact with the catalyzer at a temperature of about 700°, a cooling chamber in which the ammonia is liquefied and removed from the system, and pumps, drying agents, etc., to return the gases not acted upon to the reaction chamber and introduce fresh, dry gas. The whole system must be kept under pressures ranging from 125 to 150 atmospheres. That is one of the chief drawbacks of the process, though it is undoubtedly being operated successfully, for since the first plant was erected in 1913 by the Badische Company the output of ammonia has shown the very rapid increase from 20,000 tons $(NH_4)_2SO_4$ in that year to 300,000 tons in 1916, and it was estimated that during 1917 the output would reach 500,000 tons.

The success of the process depends in no small part on the purity of the nitrogen and hydrogen used. Comparatively pure nitrogen is obtained from liquid air. Hydrogen is made by the action of steam on hot coal or iron, and then purified before introducing into the system. The preparation and purification of hydrogen represents one of the chief items of cost in the process. The technical operation of the Haber process requires a corps of trained workmen who understand the details so necessary to its success. It is reported that if the Badische Company, who own and control the process, should lose its present technical staff of experts familiar with the process, it would be many months before another staff, capable of applying the process in practice, could be trained.

Concerning the synthetic ammonia process worked out by the

General Chemical Company, very little information is at present available. It is claimed, however, that it does not require the high pressures necessary in the Haber process, and that ammonia can be produced by it considerably cheaper than by the Haber process.

The Bucher process for the production of NaCN, though still in the experimental stage, is so simple of operation, and the raw material is so cheap and easy to obtain, that it promises to give fixed nitrogen at a cost lower than that of any other known process. Dr. Parsons, chief chemist, Bureau of Mines, says of it, "From the chemist's standpoint the process is today a success. There is no difficulty whatever in the chemical reactions. When Na_2CO_3, ground coke or carbon in any form in contact with finely divided iron are heated to redness, and nitrogen or even air passed through the mass, nitrogen in quantity is fixed as NaCN. The reaction takes place readily. No power factor of any consequence is involved, and it appears certain that if the mechanical difficulties are solved, nitrogen will be fixed in this form cheaper than by any other known synthetic process. . . . The process has the further advantage that it would also make cheaply available cyanide, which is so greatly needed by our mining industries."

In discussing his process Professor Bucher says the idea is not new but that the fixation of atmospheric nitrogen to form alkali cyanides is by far the oldest of all such methods. In 1839 Lewis Thompson, while attempting to improve the method then in use for the manufacture of Prussian blue, found that KCN is formed when nitrogen is "allowed to act on a mixture of carbon and potash under favorable circumstances." In describing his method Thompson states that he found it necessary to use iron. "When iron is not employed," he says, "a much higher temperature is required." He ground together into a coarse powder two parts potash, two parts coke, and one part iron turnings, and heated the mixture in an open crucible in an open fire for about half an hour, and obtained an abundant yield of KCN.

The announcement of Thompson's results soon led to very active discussions and investigations by some of the most noted investigators of that time, including Berzelius and Bunsen. For some reason unexplained, however, all of these investigators omitted the iron from their mixture, and as a result were either not able to obtain cyanide or were able to obtain it only at very high temperatures.

The early work of Professor Bucher on this subject consisted in the investigation of the following reactions:

$$2Na+2C+N_2 \rightarrow 2NaCN+46{,}200 \text{ cal.} \quad (1)$$

$$Na_2CO_3+2C \rightarrow 2Na+3CO-184{,}700 \text{ cal.} \quad (2)$$

Reaction (1) was found to proceed slowly, and the time required for completion was always a matter of hours. When iron was added to the mixture, however, the reaction was almost instantaneous at a low red heat. The catalytic effect of iron was therefore established. Its commercial application would depend on the possibility of obtaining cheap sodium. The applicability of reaction (2) was investigated for this purpose. A number of experiments combining the two reactions showed that cyanide could be prepared very readily at temperatures about 860° to 950° when iron was used as a catalyzer, but that appreciable quantities could not be obtained below 1000° in the absence of iron. This established the principle of the reaction. The next problem was to transform the laboratory experiment into a commercial possibility.

To get rid of the inconvenience of passing nitrogen over a powder, such as would be formed by the intimate mixture of Na_2CO_3, carbon and iron, briquettes were made. Of the methods tried out, that which gave most satisfactory results was as follows: The iron or hematite and carbon were ground separately until they would pass through a 100-mesh sieve. The two were then mixed and the grinding was continued for about an hour. The Na_2CO_3 was then added, and the mixture ground for about five minutes longer. The dry product was then placed in a steam jacketed mixer, and enough hot water added to make a thick paste. The briquettes were made by forcing this pasty mass through an ordinary meat grinder provided with a plate containing holes one-eighth inch in diameter. The knife was adjusted so that pieces about an inch long were cut off. These were dried in an oven. They formed a hard, dry briquette, quite free from dust.

It was found necessary to use hot water in the mixing in order to assure the formation of the monohydrated sodium carbonate since the formation of any of the decahydrate caused the briquettes to crumble on drying. The transition point from the deca- to the monohydrate is at 35°. A mixture of two parts iron, two parts coke, and one part soda was found to give the best results. It was also shown that air, producer gas, or even gas from combustion chambers could be used in place of nitrogen in the reaction.

Both a batch and a continuous furnace had been tried out on an experimental scale and found to work quite satisfactorily. Certain mechanical difficulties, however, have prevented placing it immediately on a commercial scale. The chief object of the Government's investigation will be to solve those difficulties.

The extraction of the NaCN from the reaction product is accomplished in either of two ways, by distillation or by leaching. By the distillation process the cyanized briquettes are heated in a closed vessel to about 1000° and at 2 mm. pressure. The cyanide distills over and collects in a pool which solidifies to a clear glass. The method is claimed to effect an almost complete separation. It is necessary to observe certain precautions in the leaching process, owing to hydrolytic action on the NaCN, the formation of ferrocyanide, and the tendency of the dihydrate (NaCN, $2H_2O$) to "set" like plaster of Paris. To avoid these dilemmas the lixiviation temperature should be slightly above 35°, the transition temperature of the dihydrate, and the leaching carried out as quickly as possible. The solution when evaporated to dryness gives NaCN sufficiently pure for many purposes.

An idea of the cost of fixed nitrogen by this process may be had from the reactions involved. The reaction

$$Na_2CO_3+4C+N_2 \rightarrow 2NaCN+3CO-138{,}500 \text{ cal.}$$

would theoretically require 35,000 h. p. to produce 180,000 tons of HNO_3, allowing 85 per cent efficiency in oxidizing the ammonia. The three molecules would give on burning

$$3CO+1\tfrac{1}{2}O_2 \rightarrow 3CO_2+200{,}000 \text{ cal.}$$

equivalent to about 50,000 h. p. to help make up the unavoidable heat losses. Combining the two reactions it is seen that the total reaction is exothermic, showing at least that the power factor is of little consequence. The great simplicity of the process and the low cost of the materials used also indicate that the method should produce fixed nitrogen at a very low cost as compared to other processes now in use.

THE SOLAR ECLIPSE OE JUNE 8

By William B. Thomas,
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Since eclipses recur in a cycle of eighteen years, eleven and one-third days, nearly, the solar eclipse of June 8 is regarded as a repetition of that of May 28, 1900. Since, however, this eighteen-year period, the Saros of the Chaldeans, is not an exact dividend of the days in the year combined with the moon's motion, each succeeding appearance of the corresponding eclipse comes some eleven days later in the year; but since the earth has completed .32 of a new rotation, in other words has spun off a third of an additional day before the conditions making the eclipse arrive, at the end of the Saros, each recurrence is seen some 120° of longitude farther west than the one preceding. When it is added that every third Saros brings a specific eclipse approximately to the same longitude, it will be seen that anyone who will apply the sense of the facts just given, as far as they go, is predicting an eclipse, in a rough way.

The general conditions of the event being now given, the eclipse of June 8 may be examined. If the rotational motion of the earth were to cease for the afternoon of that date, at about 3:35, counted as Chicago time (or 4:35 counted as "daylight-saving-time" at Chicago), from a very high aeroplane, properly situated, a shadow, moving from thirty to forty miles a minute in the general direction, southeast, might be seen starting to flit over the continent. It would enter off Washington and leave the continent off Florida. We are supposing the earth to stop, but the usual phenomena of time and daylight to go on. This could not be, and, in reality, the minute of arrival, anywhere, of this unusual shadow is complicated by factors, such as the latitude of the observer, his nearness to the exact center of totality, and, of course, the rotational motion of the earth. The shadow moves forward like that of a cloud seen over a hilly countryside, but in a manner calculable mathematically.

The general data of eclipses are well enough known. For example, Oppolzer's lists trace all eclipses occurring for over eight centuries. The following years will bring total eclipses visible in the United States, namely: 1918, 1923, 1925, 1945, 1954, 1979, 1984, and 1994. Obviously, all these are not that of 1918 repeated. The same definite locality will not observe a total eclipse oftener than once in 360 years. The Naval Observatory publishes in the *Nautical Almanac* exact circumstances

of eclipses each year. Owing to the line of totality, full calculations, this year, are given for Denver, Col., with local circumstances for seventy-seven other points. These circumstances, as they are called, are concerned with the time, magnitude, and angle of the shadow at the beginning, middle, and end. The region of totality must be considered favorable this year. The eclipse may be observed at places easily accessible, and the uncalculable meteorological factor stands a good chance of being auspicious. The corresponding eclipse of 1900 appearing about 8 o'clock in the morning, in the Rocky Mountain district, was seen as a partial eclipse in a perfectly clear sky. The various matters of addition to theoretical knowledge which await the coming of a total eclipse render it sure that even war conditions will not prevent a careful scrutiny of this phenomenon, the present June, and the leaving of records for the future. Quite obviously, since science is progressive, equipment for study was never before quite so perfect for the making of an observation. The minute or two of totality shown in the *Almanac* on page 561 as occurring on the central line will be a time of close watching and careful comparison.

The area of totality for a total solar eclipse being narrow and variable, each observer who cares to do so may calculate for himself such items as (1) *position of point of contact*, (2) *time of maximum eclipse, and* (3) *magnitude of maximum eclipse.* A glance about page 729 of the *Almanac* will show the laboriousness of this work. It will readily appear that it is done largely by division of labor and the sharing of results. The reader, however, cannot inform himself of the processes employed better than by a following of the descriptions given in standard texts on the subject, and especially in the *Nautical Almanac.* What are known as the Besselian elements are used; in other words, the problem is stated geometrically, these elements of the problem are supplied by the *Almanac,* and calculations are then made. The formulas employed, respectively, for the items enumerated above will illustrate the method, though they will not be fully intelligible without reference to page 728 of the *Almanac.* They are:

$$P = N + \psi \tag{1}$$

$$\tau = \frac{m \cos(M+N)}{n} \tag{2}$$

$$D = \frac{L - \Delta}{2L - 0.5446} \tag{3}$$

THE DOCTRINE OF FORMAL DISCIPLINE.

By Nathan A. Harvey,

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I have been much interested in the attempted defense of the doctrine of formal discipline by Professor Young in the January and February numbers of School Science. I refer to the articles upon "Transfer of Training," and the "Disciplinary Value of Studies."

Professor Young objects to the statement of the doctrine in the writings of many opponents of it, saying that "Even opponents seldom set up a careful definition of the doctrine, and when a definition is set up, it is done with the avowed purpose of knocking the doctrine down" (p. 132). Then Professor Young asks, "Was there ever anyone who seriously held this prostrate doctrine?" Also, Professor Young seriously objects to Heck's statement, with its implications and its illustration of the release of water through different pipes from a common reservoir. In a comment upon Bagley's statement of it, he reiterates the question, "Who ever held such views?"

I am inclined to believe that Heck's statement is fairly representative of the doctrine, although I would prefer to use my own statement. It is exceedingly dangerous for a man to quote from his own writings, but I am going to venture to do so in this case. In a book, *Principles of Teaching*, which I sincerely hope Professor Young will never see, I have used such expressions as these: "Some persons have undertaken to establish mental discipline as the true purpose (of education). It is believed that the real purpose of education is not the accumulation of knowledge but the training of the mind. The mind, through its processes of learning, becomes able to do what otherwise would be impossible for it" (p. 70). "They affirm that it is not the knowledge of the subject which is the matter of special importance, but that in the study by which the knowledge of the subject is gained, power and ability to do mental work in any direction is acquired" (p. 71). "The psychological theory, under the influence of which this idea of mental discipline has been developed, assumes that the mind has certain powers which need to be cultivated" (p. 71). "It assumes (the theory of mental discipline), as a fundamental postulate, that power gained in the study of one subject is capable of being applied to the study of any other subject" (p. 73).

If this is a man of straw, I should like to exhibit some of the straw of which the man is made.

1. All studies give useful information, and all studies can be so pursued as to aid in the development of mental power. And however valuable the knowledge gained, the growth of power should be the chief aim of all our school work.[1]

2. Any power under the control of the will may be cultivated, or trained.[2]

3. The powers are trained in one way, and in one way only; viz., by wise use.[3]

4. Any power of the mind grows strong by the activity of that power against appropriate resistance.[4]

5. The several powers are developed by occasioning the natural activity of each. Exercise strengthens faculty.[5]

6. In the primary school period, perception is trained by handling and observing objects; memory incidentally by all the work of the grade, and in special ways by memorizing gems of literature; imagination by tales and descriptions, and such designs and constructions as are employed in the kindergarten; the thinking faculty by use of simple judgment and reasons; proper emotion is fostered in many ways adapted to the dispositions and needs of the child; the will is strengthened by the restraints and demands of the school room.[6]

7. (During the high school period.).....The Inductive reason is trained by inductions in science and history, the deductive reason by mathematics, the finer emotions are developed in the study of literature.[7]

8. Now mental activity is, strictly speaking, one and indivisible. The mind is not a complex substance, composed of parts, but single and one.[8]

9. .....The simple truth (with large implications) is that each soul is one thing, a unity, an essence, spiritual in its nature, and thereby absolutely indivisible.[9]

10. Remaining always a one thing, this one thing is developed

[1]Hewett, *Pedagogy*, p. 41. Dr. Hewett was President of the Illinois State Normal University, an influential teacher, whose teachings are still exercising a marked influence upon educational practices, and who reflected in a very complete way, the psychological opinions of his time.

[2]Hewett, *Pedagogy*, p. 45.

[3]Hewett, *Pedagogy*, p. 45.

[4]Salisbury, *Theory of Teaching*, p. 241. Mr. Salisbury was President of the State Normal School at Whitewater, Wis., a very influential teacher, whose book is still widely used, and who represented in rather a satisfactory manner, the psychological opinion of his day.

[5]Salisbury, *Theory of Teaching*, p. 245.

[6]Baker, *Elementary Psychology*, p. 163. Mr. Baker was President of the University of Colorado, a Past President of the National Education Association, member of the Committee of Ten, and knew the psychological and educational theories of his day.

[7]Baker, *Elementary Psychology*, p. 164.

[8]Haven, *Mental Philosophy*, p. 29. This was a very representative and popular textbook on psychology.

[9]Jones, *Education as Growth*, p. 23. President Jones was Superintendent of Schools in Indianapolis, Cleveland, and President of the Michigan State Normal College. He represented well a very large body of educational theory and practice.

and made greater and more worthy or powerful, through the proper exercise of these capacities; and the process by which such increase of power, or worthiness, is gained, is properly called education, whether attained in school, or in other disciplines of life.[10]

11. I believe that four years of high school Latin is best for the ordinary high school boy or girl, because of the mental training involved.[11]

12. May I repeat.....a student properly trained in the Greek and Latin languages, and in mathematics,.....comes to the university equipped to attack successfully whatever is offered him.[12]

I have selected the above extracts from the first half-dozen books picked up from my table. I believe that a very brief search through the library would enable me to multiply the number of similar quotations by a hundred. It seems to me that there is abundant material in these few quotations to justify every phrase in the statement of the doctrine of formal discipline outlined above. It appears also, that there is in these few quotations a sufficient answer to Professor Young's rather contemptuous inquiry, "Who ever believed that?"

The doctrine of formal discipline is still influential. It is believed in by many persons. It is, however, inconsistent with the Herbartian doctrine of apperception, and anyone who adheres to the apperception doctrine cannot adhere to the doctrine of formal discipline. It is also inconsistent with the doctrine of localization of function, and if the doctrine of localization of function has been established, the doctrine of formal discipline has been disproved.

The doctrine of formal discipline assumes that the mind is a thing, with certain powers that can be strengthened by exercise. Modern psychology knows nothing of this power-possessing thing, and consequently the doctrine of formal discipline falls with the assumption which is necessary to it.

I believe that there is sufficient evidence from experimental studies to justify our belief that the doctrine of formal discipline has been disproved by experiment. The results are not so convincingly complete as to amount to demonstration, nor sufficiently strong to convince a person who is unwilling to give up the doctrine, that he must do so. Certainly, however, the result of experiment lends no comfort to the advocates of the doctrine, and all psychological tendencies are against it.

[10]Jones, *Education as Growth*, p. 23.
[11]Francis Ramalay, *University of Colorado Bulletin*, 1914, Vol. XIV., No. 9, p. 33.
[12]John B. Ekeley, *University of Colorado Bulletin*, 1914, Vol. XIV, No. 9, p. 18.

SOME PHASES OF SPRING NATURE STUDY.

By C. F. Curtis Riley,
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The spring is always an interesting period for the study of outdoor life. At this time of the year many animals and plants are arousing from the lethargy of winter. Therefore, the spring brings with it ample opportunities for nature study work. While the summer may be considered to be the more ideal season for out-of-door study, yet the spring is the most favorable time for certain kinds of nature study observations. In fact, some phases of such work can be undertaken only at this time of the year.

Bird study is a profitable phase of nature study, in the spring. The identification of the spring birds offers many interesting and unusual experiences. The color, form, and size of a bird are useful factors in the process of identification. The song of a bird is frequently helpful in naming the species, even when the creature itself is not visible. Some peculiarity of flight is often the only factor necessary to identify the bird. When a bird is on the ground, or in a tree, certain characteristic movements of the tail, head, or wings are sufficient to materially assist the observer in recognizing the species. There are many books on birds, but they are not all of equal value for purposes of bird identification. The following books are recommended as being reliable for this purpose: *Handbook of Birds of Eastern North America*, by F. M. Chapman; *Color Key to North American Birds*, by F. M. Chapman; *Bird Life*, by F. M. Chapman; *Wild Birds in City Parks*, by H. E. and A. H. Walter; *Birds of New York*, Part 1; Part 2, by E. H. Eaton; *Bird Guide*, Part 1, "Land Birds"; Part 2, "Water Birds," by C. A. Reed; *How to Know the Wild Birds of Illinois*, by D. Lange; *A Guide to the Birds of New England and Eastern New York*, by R. Hoffmann; *Birds of the Western United States*, by F. M. Bailey; and *Birds Through an Opera Glass*, by F. A. Merriam. Many other books, besides those that have just been enumerated, treat upon the subject of the identification of birds, but it is believed that any one of these will prove to be very useful in assisting the beginner to become acquainted with a large number of the common species.

Besides identification, there are other phases of bird study that are fully as interesting and equally valuable. The spring provides an excellent opportunity for work of such character.

The return of the birds always creates an interest in some of their more obvious forms of behavior, among groups of people of varying interests. At this season of the year many species of birds are actively migrating. For some time, different species may appear each day. In connection with the study of bird migration, the preparation of a bird calendar provides an interesting method of recording valuable data. The following are the more important facts to be recorded: the name of the bird, the date on which it was observed, the location of the bird, the name of the person who made the observation, and finally any general remarks concerning the bird. Under the last heading, such questions as these may be answered: was the bird feeding, and what was the nature of the food; was the bird building a nest; was the bird observed in some unusual position; was it on the ground, or in a tree, etc.? It will prove very interesting to notice the variety and number of species that are recorded in so short a period as two weeks. A valuable comparison can be made between the variety and number of species recorded during the first week of observation and the variety and number of species of the last week of observation. After the bird calendar observations have been recorded for a month or more, a summary should be made. When this is done, special attention should be focused upon the preponderance of certain species of birds and the scarcity of others. The weather conditions and the abundance or the sparseness of food should be noted, carefully.

Many species of birds are relatively tame during the early spring. The instinct of fear appears to be subordinated at this time, while the food, nesting, and migration instincts predominate. The subordination of the instinct of fear is very noticeable during the breeding period. Advantage should be taken of these facts in order to study the bird habits that predominate at this season of the year. In connection with food habits, particular attention should be directed to the kind of food sought by the birds and also to the behavior of the birds in obtaining such food. Observations of this character, if carefully made, may be of permanent value, especially to the gardener and the farmer. Many of the spring birds are found to be seed eaters; some are observed to seek insects as food; others eat the buds and early fruits; and still others prove to be mixed feeders.

There are few of the spring habits of birds more fascinating

to the observer than that of nest building. It is well worth the time necessary for observation to notice the different kinds of materials used by different species of birds during this process. In general, it may be stated that song birds use grass, hair, small twigs, and fine fibrous roots in building their nests. Some species of these birds plaster such materials together with clay and mud. The coarser materials are placed at the bottom, or foundation, and on the outside of the nest. The finer materials are worked into the upper and inner parts of the nest. Frequently the nests of these birds are lined with feathers. It may be worth while to recall, specifically, the materials used in nest building by several different species of birds. The house wren builds its nest of sticks and twigs, and lines it with grass, feathers, and cottonwood down. The Baltimore oriole uses building materials of hair, string, grasses, and bark fibers. These are formed into a sort of network, and are woven together, the process displaying much skill on the part of the bird. The result is a little swinging sack, placed at the end of a branch, high in a tree. The nest of the ruby-throated humming bird is built very compactly, and it is very small in size. It consists mainly of moss and plant fibers, covered externally with lichens, and lined with cotton. It is also of interest to observe where the birds obtain the building materials. Much of this is found in the immediate vicinity where the nest is to be located, but some of it may be brought from considerable distances. For example, a Baltimore oriole was watched as it picked up in its bill pieces of string and carried them away to be woven into its nest. The string had been thrown onto a refuse pile directly under the soft maple tree in which the bird had built its nest. Another example was that of a robin which was observed to carry mud, for nest building, for a distance of a quarter of a mile.

Certain species of birds are much more difficult to observe than others. This applies not only to nest building habits, but also to other habits as well. Therefore, it is decidedly worth while to make a careful selection. The following common birds have been found to be suitable for the study of habits: the robin, the meadow lark, the catbird, the house wren, the Baltimore oriole, the house sparrow, the blue jay, the brown thrasher, and the black-billed cuckoo.[1] The study of bird

[1]Herrick, F. H., "Life and Behavior of the Cuckoo," *Jour. Exper. Zool.*, Vol. 9, pp 169–233, 1910.

habits and general bird behavior is becoming more and more a most important feature of general bird study In fact, many valuable and interesting facts have accrued to genetic animal psychology through observations of this character.

Another valuable form of nature study work, at this season of the year, is the observation and study of the early spring flowers. There is a certain degree of satisfaction, in fact a fascination, in discovering the first violet or the first anemone. It is also an interesting experience to find flowers in unusual locations. I had frequently heard of violets growing in close proximity to snow banks, but not until I found them in such a location, near Duluth, Minnesota, did such a statement have any real meaning for me. Favorable spots to look for spring flowers are sunny banks, open timber, and protected hillsides. Some of the best of these early spring flowers should be collected, carefully pressed and dried, for the purpose of forming a herbarium. The making of a spring flower calendar is just as interesting and just as valuable as the making of a spring bird calendar. The date of the observation of the flower, the kind of flower, the location of the flower, and the approximate number of individual flowers of different species in a specific location, are all facts worthy of record.

The study of trees in their early and late spring conditions presents many profitable lessons in nature study. Their grouping and classification is an interesting phase of study. The form of the tree, the character of the bark, the method of branching, and the type of buds should all be considered in work of this nature. Such trees as the pines, elms, maples, birches, oaks, butternuts, basswoods, ashes, and hickories are especially suitable for this sort of observational study. The appearance of areas of color in our forests, during the early spring, is an interesting phenomenon. The outer layer of tissue is thin and somewhat translucent on the young twigs of certain species of trees, and as the spring progresses, this region displays touches of color. This is evident on the young stems that still retain the epidermis, the thin external layer, and on which the periderm, a form of secondary growth that supplants the spidermis, has not yet developed, or at least has not fully developed. The presence of this color is a result of the renewed chemical and physiological activity, which occurs in the spring of the year. It is due to such changes as these that the coloring becomes evident in our northern woods before the buds have opened,

thus producing an aesthetic effect in the leafless forests. Attention should be directed to the various types of buds, and to their manner of unfolding. It should not be forgotten that trees belong to the true flowering plants. While these flowers are not nearly so showy as the flowers of our gardens, they are none the less true flowers, possessing all the possibilities of such structures.

The brook, as an insect habitat in the spring, will well repay even the most casual observer. The whirligig beetles that spin in dizzy circles on its glossy surface are a never-ending source of wonder. One speculates in amazement upon the evolution of such an astonishingly peculiar form of behavior. On picking one of them from the surface of the water, its body is found to be hard in texture and of a blue-black color. It possesses wings and three pairs of legs. While these insects fly with ease, they apparently do not fly directly from the surface of the water, but first must climb up the stem of some aquatic plant. The eyes are separated into two parts, and it has been inferred that one serves for vision in the air and the other for vision in the water.

One finds also that several species of diving beetles are inhabitants of the brook. It is very interesting to watch one of these insects suddenly come up to the surface for air, and then, just as suddenly, dive down again to the bottom of the stream. Some of these beetles and their larvae are decidedly predacious. This is especially true of that group, or genus, of beetles known as the *Dytiscus*. The larvae feed on other insects, worms, snails, and tadpoles. Some writers state that small fishes also become their prey. It is interesting to notice that the structure of the body of diving beetles is well adapted to an aquatic existence. The legs are broad and flat, and they are functional in swimming, being used much in the same manner as are the oars of a boat. The surface of the body is smooth, thus the friction of the water is reduced. The boat-like configuration of the body suggests adaptation to the mode of life of the insect. An interesting fact to the nature study student is that these beetles and their larvae thrive well in aquaria. The observer then notices that such creatures lead a very active life. In confinement, their various forms of behavior, such as swimming, diving, breathing, capturing prey, and feeding are observed readily.

Several species of water striders are found to be skating gracefully over the surface of the stream. The bodies of these

insects do not touch the water. The legs are very long and slender and are stretched widely apart. These structures support the body and raise it above the surface of the stream. These interesting creatures do not break through the surface film of the water, but they are supported by it, and glide about on its surface. The striders constantly face the current, upstream. This is a form of response which probably is adaptive, as it provides them with food, in the form of insects, which floats downstream.

In the shallower water of the brook, where it forms small ripples as the current flows over the rocks, stones, and gravelly bottom, frequently are found the larvae of the caddice fly. In such a location, food can be carried to the larvae by means of the current. These creatures are observed to be some distance below the surface of the water, attached to rocks, stones, aquatic plants, and the gravelly bed of the stream. Some kinds of caddice fly larvae are more or less active in obtaining food. If a number of the larvae are examined, it is noticed that the cases, or sheaths, which vary very much in shape, entirely surround their bodies. Careful observation discloses that some of the cases, containing larvae, are not attached to any solid object, and although the sheaths, frequently, are constructed of heavy materials, they are carried about easily, because of the buoyancy of the water. In general, the cases are cylindrical in outline. However, they may be flattened, irregular, rough with sharp projections, smooth, or symmetrical in configuration. The body of each larva is surrounded by a tube, made from a silky material which is produced by the animal itself. This silk-like cylinder forms a lining within the sheath, which forms the outer wall around the body of the larva. The cases of the caddice fly larvae are built out of various different materials, such as portions of leaves, particles of gravel and stone, and small pieces of wood. Sheaths have been found that were formed from fragments of aquatic plants, the genus *Equisetum* for example. Some are so constructed that they exhibit a fine symmetry, while others are totally lacking in this quality. The various parts of which the cases are composed are fastened together by means of the silk-like material which is spun by the larvae. This substance is somewhat viscid, which property is of decided value in holding together the individual parts of the sheath.

The larvae of the caddice fly are often spoken of as caddice

worms. They are worm-like, or caterpillar-like, in general appearance. From this stage of development, they are transformed into pupae. Frequently, during the larval stage, the two ends of the case may be open. Through the front opening, the larva protrudes its head. After the larva begins to metamorphose and before it passes into the pupal stage, these openings are closed by the creature itself. The two ends of the case may be closed by means of the mucilaginous, silk-like material that has been mentioned previously, or these apertures may be closed by the use of some other substance. I have found pupae in brooks during the months of May and June in such diverse localities as Duluth, Minnesota; Milwaukee, Wisconsin; Urbana, Illinois; and Covington, Indiana. Occasionally, I have observed them earlier than this. Such examples may have passed the winter in this condition. Sometimes the pupal cases are found to be considerably shorter than those in which the larvae are enclosed. When the pupa is ready to transform into the mature caddice fly, it crawls up the stem of some aquatic plant, or other support, which extends above the surface of the water. After reaching the open air, the mature caddice fly emerges. Soon the wings expand, become dry, and the insect flies away. Some species of this insect transform beneath the surface of the water. The mature insects are superficially similar to the group to which the butterflies and moths belong. They are dull-colored creatures, frequently brownish. They have four wings, which are veined. The feelers are long and slender. They are not very strong fliers, but they make short flights in the vicinity of the stream from which they have emerged.

There are many other interesting forms of life in the brook. Besides those creatures that already have been described, there are water boatmen, back swimmers, water scorpions, May fly nymphs, and many other curious types of insect life, all of which possess their own interesting and individual forms of behavior. The water boatmen are oval in form, in color, a greenish gray and black. They are small insects, none more than half an inch in length. While swimming, the back is uppermost, and the long hind legs serve the purpose of oars. These creatures are able to stay below the surface of the water for a considerable length of time. The structure of the body of the back swimmer is somewhat peculiar. If one of these insects is observed carefully, it will be noticed that the back is shaped

like a boat. The hind legs are long, flattened, and fringed with hair-like projections. These long appendages assist the insect in swimming. They swim with the back down, always. Frequently, they will remain at the bottom of the brook for long periods of time. This peculiar habit, on the part of these two insects, of remaining below the surface of the water, is not fully understood. It is known that air clings to their bodies in the form of bubbles. These are found under the folded wings and also on the under side of the body. The observation of the instincts, habits, and other types of behavior of aquatic insects, opens up a wide, varying, and profitable field of nature study, which, if properly pursued, will lead to results that might possess elements of scientific importance and of economic value.

No nature study work in the springtime of the year would be complete without the consideraton of its aesthetic side. The colors of the flowers, the sounds of the brooks and of the waterfalls, the songs of the birds, and the scents of the woodlands all have their place in an appreciation of the beautiful in nature, as reached through the senses. This phase of the subject, if it arouses true and rightful emotions, tends to develop more harmonious relations between the individual and the environment, and is, in all probability, as valuable in its development of the self as is the more strictly intellectual study of nature. Any scheme of nature study that does not entertain a proper consideration for the purely aesthetic aspect, just to that extent falls short of presenting a most necessary and vital phase of training in individual development.

UNIVERSITY OF CHICAGO.

Alumni and students of the University of Chicago are in the Army to the number of approximately 1,200. About seventy-five of the faculty are engaged in war service, either in the Army or in other services directly connected with the prosecution of hostilities. One of the faculty, Major Henry Gordon Gale, who is Professor of Physics and Dean in the Colleges of Science, is now in France, and one of the University Board of Trustees, Mr. Francis W. Parker, has charge of important work with the Young Men's Christian Association in the American camps in France. The scientific laboratories of the University, which were at once placed at the service of the Government on the outbreak of war, have been doing much important work since.

ERRATUM.

The following should have been inserted in connection with Figure 6, Dr. Cole's article, on page 453 of the May issue of this Journal.

Figure 6. Inheritance of wilt resistance in flax. At left, the resistant parent; at right, susceptible parent (only a few plants left, and these are sick); in the middle, the vigorous resistant cross between the other two.

SOME PRECISE METHODS OF FOCUSING LENSES.

By LeRoy D. Weld,
Coe College, Cedar Rapids, Iowa.

In the course of some recent experimental research with polarized light,[1] the writer had occasion to calibrate the focus of an optical instrument for varying wave length with particular care, in order to eliminate the error due to a sort of parallax which gave trouble when the photographic plate was slightly out of focus. It was, in fact, this very parallax which was utilized for the purpose of adjusting the focus in the former of the two methods herein suggested.

The method depends simply on the crossing of the rays of the convergent light at the focus of the lens, the light which is to one side of the instrumental axis in front of the focus being on the other side of it back of the focus. The ordinary method of obtaining the focus by judging the sharpness of an image, while satisfactory for many visual purposes, is not precise at best.

I. To Focus Upon an Object—Broken Prism Method.

If the lens or lens system is to be used to form a real image of a sharply defined object, as an illuminated slit or cross hair, the problem is to find the exact location of that image. For example,

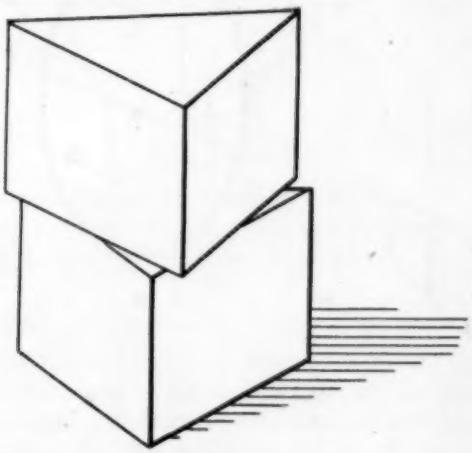


Fig. 1

in the writer's research apparatus, the lens, which was of quartz, with a 30 mm. aperture, had a focal length of about 19 cm., and the object was an illuminated hair line about 33 cm. distant, whose image was therefore produced about 43 cm. back of the

[1]Weld, *Physical Review*, N. S. XI, p. 249. March, 1918.

lens. An eyepiece directly back of the plate holder, used for aligning and focusing the instrument, magnified the image on the ground slide, or could be used if desired without the slide, as in a telescope. In either case, it was found that the focus could not be adjusted with certainty within several millimeters by the ordinary method, especially when the illumination was faint, as with deep violet light.

The following device was therefore adopted: Two similar glass prisms with polished faces are placed, one on top of the other, with the corresponding faces making a slight angle (say, two or three degrees), as shown in Figure 1. An approximately parallel beam of light of the wave length desired is reflected from this arrangement into the instrument to be tested, the upper half of the beam from the upper, the lower half from the lower prism, so that the two reflected beams gradually separate, like the nearly closed blades of a pair of shears; and they consequently stream past the cross hair (or through the slit) in slightly different directions.

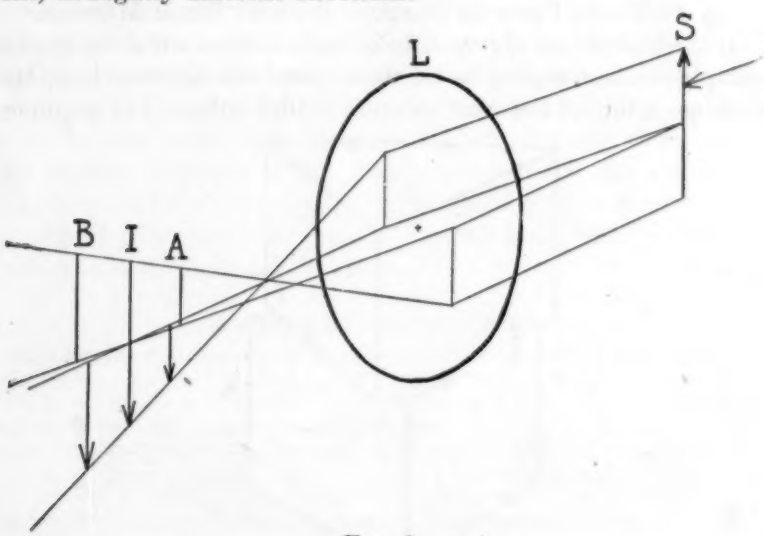


FIG. 2

Figure 2 will help one to trace the paths of the light from this point on within the instrument. An inverted image I of the hair (or slit) S is formed at the focus of the lens L, the upper beam being responsible for the lower half, and vice versa. But at points either a little in front of the focus, as A, or a little back of it, as B, there appears a distinct offset or discontinuity in the linear image, which is in opposite senses in the two cases; so

that if the screen or eyepiece be moved backward and forward along the axis, the upper and lower halves of the image apparently move to and fro laterally in opposite directions, meeting each other only at the focus (Figure 3).

By this means, the position of the focus may be obtained very accurately. In the writer's experiments, using a focus tube moved smoothly by rack and pinion, the probable error of a single setting was found, from a large number of observations, to be only about .45 mm., and for the average of ten, therefore, only about .15 mm. A very smooth calibration curve was thus obtainable.

The method adapts itself also to cases where the illumination is faint, and to ultra-violet; for by exposing plates at points near the focus, such as A and B (Figure 2), the two false images are obtained, from which, by measuring the offsets on the plates, the position of the true image I can be calculated by interpolation.

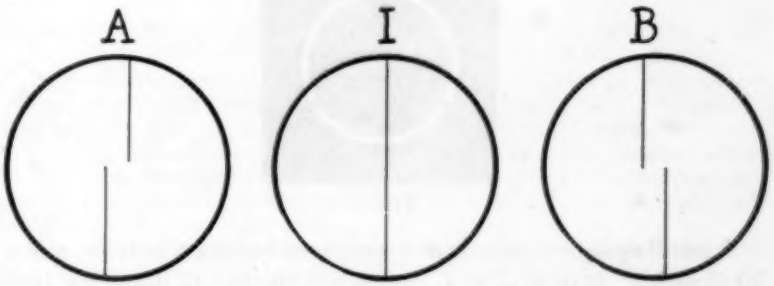


FIG. 3

II. TO FOCUS FOR PARALLEL RAYS.—ANNULUS METHOD.

A modification of the principle has been subsequently employed with lenses which it is desired to focus accurately for parallel light.

In the case of a telescope, there is probably no more accurate way of focusing for infinite distance than that of the sharpness of the image of a star, and (if there is a reticle) the absence of parallax between image and reticle wires. But this method may not always be convenient, and is not adapted to calibration for wave length.

If an accurately calibrated collimator is available, having a narrow slit, the same "broken prism" method can be used by directing the split beam upon the collimator slit, pointing the instrument to be adjusted into the collimator, and focusing it so that no offset appears in the slit image; for then the colli-

mator objective and the other lens act as a single lens system. Or, conversely, if one has a telescope accurately calibrated for parallel light, the collimator can be adjusted by the same device.

But the modified method above referred to assumes no calibrated instrument. It requires, however, a bright beam of accurately parallel light, as from the sun; or such a beam may be more conveniently obtained by focusing the condensers of a stereopticon upon a small pinhole and then adjusting the objective beyond until a strictly cylindrical beam results. This may be tested by noting that if two parallel wires be placed in it, the distance between the centers of their shadows on a screen remains sensibly constant as the screen is moved to and fro along the beam. Various wave lengths can be obtained by placing suitable color screens before the pin hole.

FIG. 4

A small opaque screen is now prepared having a narrow, annular opening, as in Figure 4, somewhat smaller in diameter than the aperture of the lens to be tested. It may be cut from sheet metal or cardboard, or drawn with dividers on smoked glass. The lens is mounted in the monochromatic, parallel beam and the annular opening placed centrally in front of it, so that a thin, cylindrical shell of light enters the lens parallel to its axis. The lens transforms the cylindrical shell into a cone, whose apex is the focus. A translucent screen placed in this cone will show a sharp ring at every point either in front of or behind the focus, but at the focus, the ring vanishes to a point—a very pretty experiment, by the way, for elementary students. If an eyepiece is used without the translucent screen, the ring will shrink to a point when the focal plane of the eyepiece coincides with the focus of the objective. It should be stated, however, that somewhat better results are obtained when it is possible to catch the image on a screen.

This method has been used by the writer for testing the

figuring of a lens for spherical aberration; for by using annular openings of different diameters, the lens is tested at different radial distances from its center, and the spherical aberration revealed by a variation in focal length. If only one test is made, it is well to have the diameter of the annular opening about .7 that of the lens aperture, thus making the lens areas within and without this circle about equal, so as to approximate an average focal length.

As an illustration, the writer calibrated for parallel light, by this "annulus" method, a glass lens of 45 mm. aperture and focal length about 20 cm., and found the probable error of a single setting to be about .6 mm., or .2 mm. for the average of ten settings; which compares favorably with the precision of the "broken prism" method.

It is hoped that adaptations of these two methods may be found useful to experimenters with optical benches, spectrometers, etc., and to optical workers generally.

RESOLUTION ADOPTED AT ATLANTIC CITY MEETING OF EDUCATIONAL PRESS ASSOCIATION.

Whereas, The Zone System for determining the rate of second-class postage established by the war revenue act of October 3, 1917, will greatly increase the cost of publications having a national circulation; and

Whereas, Periodical magazines are one of the most potent factors in education, presenting the best current thought on cultural, political, and economic lines, and supplementing the work of the schools and colleges; and

Whereas, The Zone System of postage increase will hinder the free, and easy, and even circulation of the best thought of the country to its remote sections; therefore, be it

Resolved, That the Educational Press Association of America, in annual session at Atlantic City, earnestly recommend to Congress that the Zone System be repealed.

FOREST R. MOULTON.

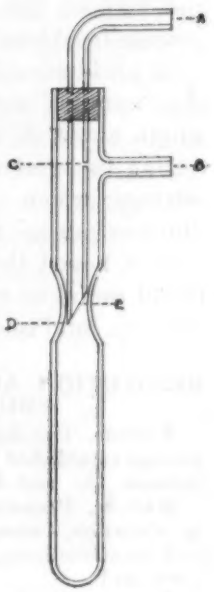
The University of Chicago Board of Trustees has granted leave of absence to Professor Forest R. Moulton, of the Department of Astronomy and Astrophysics, for one year, from April 1, 1918. He is commissioned Major in the Ordnance Reserve Corps of the United States Army, and will have the duty of directing the computation of range tables and all exterior ballistic data connected with trajectories of shell and shrapnel of all calibers, for both low-angle and high-angle fire.

Professor Moulton, who received his Doctor's degree from the University of Chicago *summa cum laude*, is an associate editor of the *Transactions of the American Mathematical Society*, research associate of the Carnegie Institution, fellow of the Royal Astronomical Society and of the American Association for the Advancement of Science, member of the National Academy of Sciences, and honorary foreign associate of the British Association for the Advancement of Science. Among his published works are *Celestial Mechanics*, *Introduction to Astronomy*, *Descriptive Astronomy*, and *Periodic Orbits*.

TEMPERATURE CONTROLLER.

By T. S. Huxham,
Montclair High School, New Jersey.

The instrument shown in this drawing is a simple and efficient temperature controller for use in water, oil, or sand bath, or in a drying oven. The materials needed to construct such a controller are: a hard glass side-neck test tube (about six inches by three-quarters) with a one-hole rubber stopper to fit, a piece of glass tubing (about ten inches long), and about three-quarters of a pound of mercury.



The side-neck tube is heated in the middle and drawn to form a constriction (see drawing). The glass tube is sealed at one end and a hole blown at C. This hole is made larger or smaller until it will allow only sufficient gas to pass through to keep the burner, with which the controller is to be used, lit. The sealed end is then cut off obliquely as shown at E. Make a right angle bend at opposite end of tube and fit stopper so that the tube may be adjusted easily.

To operate, fill test tube to D with mercury. Gas enters from top at A and leaves to go to burner at B. Place lower end of controller in bath or oven. When heat expands mercury, the hole E will be closed and only sufficient gas to keep burner lit will pass through C. After a little experiment the controller will be found extremely simple to operate and entirely satisfactory in controlling the temperature.

HIGH-GRADE ABRASIVES.

Tremendous expansion in manufacturing in 1917, particularly in the steel and metal industries, is reflected by the increased production of high-grade abrasive materials in the United States. A preliminary compilation by Frank J. Katz, United States Geological Survey, Department of the Interior, of reports on the production of emery, corundum, and artificial abrasives in 1917 indicates a total of 72,276 short tons, valued at $8,325,312, which is an increase of 33 per cent in quantity and 172 per cent in value as compared with 1916.

The production of emery from the Peekskill district, N. Y., amounted to 14,842 short tons, very little less than in 1916; the production of corundum in North Carolina was 820 short tons, a large increase over 1916; and the production of crude artificial abrasive materials in the United States and Canada, which are largely prepared for use in the United States, amounted to 57,614 short tons, which was 48 per cent more than the production in 1916.

ROBERT A. MILLIKAN.

At the annual general meeting of the American Philosophical Society, held in Philadelphia on April 18, 19, and 20, Lieutenant Colonel Robert A. Millikan, who is Professor of Physics in the University of Chicago but now of the National Research Council, gave the general lecture in the hall of the Historical Society of Pennsylvania, on the subject of "Science in Relation to the War."

Professor Millikan has now been on leave of absence from the University of Chicago for more than a year, engaged in his work at Washington as executive officer of the National Research Council. As Chairman of the Physics Committee of this body it has also devolved upon Dr. Millikan to organize the scientific work of the Signal Corps, in which corps he holds the position of Chief of the Division of Science and Research. His own detailed scientific work has had to do mostly with the submarine problem and with certain problems in meteorology and signaling. Professor Millikan's volume on *The Electron*, recently published by the University of Chicago Press, has attracted wide attention among scientific men.

A MATHEMATICAL PROGRAM.

The following mathematical program was given with much success by the academy teachers at Baldwin-Wallace College, Berea, Ohio.

THE HISTORY OF π.

By Lillian Braun.

The following questions will be considered by the academy mathematics teachers:

1. To prove that you are as old as Methuselah.
2. If the third of 6 be 3, what must the fourth of 20 be?
3. Show geometrically that $1 = 0$, and $2 = 0$.
4. Thrice naught is naught; what is the third of infinity?
5. Arrange the figures 1 to 9, inclusive, in a triangle so as to count 20 in every straight line. So as to count 17 in every straight line.
6. When is a number divisible by 9?
7. Arrange the figures 1 to 9, inclusive, so their sum will be 100.
8. Write 24 with 3 equal figures, neither of them being 8.
9. If 6 cats eat 6 rats in 6 minutes, how many cats will it take to eat 100 rats in 100 minutes?
10. Do figures ever lie?
11. Can you take one from 19 and get 20?
12. To prove that $2 = 1$.
13. Can you write 30 with 3 equal figures?
14. Can you add 1 to 9 and make 20?
15. Arrange the figures 1 to 9, inclusive, in a circle, using one in the center, so as to count 15 in every straight line.
16. Arrange the figures 1 to 9, inclusive, in a square so as to count 15 in every straight line.

THE HISTORY OF LOGARITHMS.

By Helen Simpson.

17. If $x^2+y = 11$, and $y^2+x = 7$, what are the values of x and y?
18. I found \$10; what was my gain per cent?
19. What is the value of 100 to the zero power? To the zero root?
20. Express the number 10 by using five 9's in four different ways.
21. To prove that $1 = 200$ and $1 = 2000$.
22. To prove that $-1 = 1$.
23. Do the axioms apply to equations?
24. To how many decimal places has π been worked out?
25. What does a billion mean?

OSCAR L. DUSTHEIMER.

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions.*

We desire also to help those who have problems they cannot solve. *Such problems should be so indicated when sent to the Editor, and they will receive immediate attention. Remember that it takes several months for a problem to go through this department to a published solution.*

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages. In selecting problems for solution we consider* accuracy, completeness, *and* brevity *as essential.*

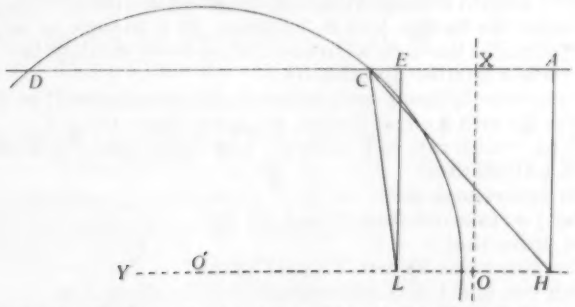
The Editor of this department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to the Editor. *Address all communications to J. O. Hassler, 2337 W. 108th Place, Chicago.*

SOLUTION OF PROBLEMS.

Algebra.

556. *Proposed by L. E. Lunn, Heron Lake, Minn.*

A fast half back finds himself free with the ball 40 yards from the side line. Thirty yards ahead of him is his only opponent, a slower man, whom he knows he can outrun by four feet to three feet. Can he escape? If not, how should he lay his course to gain the most ground before being tackled?



I. *Solution by Ruth A. David, Gibson City (Ill.) High School.*

Let H and L be the respective positions of the half back and his opponent, each 40 yards from the side line AE. HL = AE = 30 yards. If opponent's path and that of the half back's can intersect on the side line (which would prevent his escape), let it be at C. Let n = EC. Let d and $3d/4$ represent the number of yards traveled by the half back and his opponent, respectively. Then

$$d^2 = 40^2+(30+n)^2, \quad \text{and} \tag{1}$$

$$9d^2/16 = 40^2+n^2. \tag{2}$$

From (2),

$$d^2 = \frac{25600+16n^2}{9}. \tag{3}$$

Then from (1) and (3), n = 70.9 and 6.25, approximately.

If the half back is less than (30+6.25) 36.25 yards from the goal line, he can escape in a direction which will intersect the side line 36.25

yards in advance of his initial position. If he is more than 36.25 yards from the goal, his best course is in the same direction.

Discussion by the Editor.

The above solution is the only one received which answers the questions of the problem approximately, and because only elementary algebra and geometry are used in the solution the Editor considers it a credit to its author and publishes it.

A clearer view of the situation can be had, however, by the use of analytic geometry. Consider C a variable point. The locus of the point C under the conditions that CL : CH = 3 : 4 is easily found to be a circle with center O′ (O′L = 38 4/7) and radius equal to 51 3/7. This circle intersects the line AB at C, where BC = 6.25, and at D, where ED = 70.9. The line HC also intersects the circle, as shown in the figure, between H and C, and if the opponent runs in the direction of this intersection the half back will be tackled before crossing line LE unless he chooses another direction. Obviously, his best direction is just outside the tangent to the circle from H. This tangent touches at the intersection of the line LB with the circle 34 yards from L and makes an angle of approximately 48° 35′ with HL. The angle LHC is approximately 47° 50′.

To obtain the locus of C, choose for the origin of coordinates the mid-point O, of the segment HL. Let OX and OY (see figure) be the positive directions of the X— and Y—axes, respectively. Then

$$x^2+(y-15)^2 : x^2+(y+15)^2 = 9 : 16,$$

from which we obtain the equation,

$$x^2+(y-375/7)^2 = (360/7)^2,$$

whence follow the conclusions made in the preceding paragraph.

Geometry.

557. *Proposed by Clifford N. Mills, Brookings, S. Dak.*

If ABC is a triangle inscribed in a circle, and from the middle point D of the arc BC a perpendicular DE is drawn to AB, then $AE = \frac{1}{2}(AB+AC)$ and $BE = \frac{1}{2}(AB-AC)$.

I. *Solution by Arnold S. Worfolk, Student in Dickinson High School, Jersey City, N. J*

Given: $\triangle ABC$ inscribed in circle O, with D mid-point of arc BC, and $DE \perp AB$, and $AC > AB$.

To prove: $BE = \frac{1}{2}(AC-AB)$, and $AE = \frac{1}{2}(AC+AB)$.

Proof:

Take on AC, AG = AB, and AF = AE.

$\triangle DEA = \triangle DFA$,

$\therefore \angle E = \angle F = 90°$.

Also $\triangle DAB = \triangle DAG$,

$\therefore DB = DG = DC$,

and $BE = GF = FC = \frac{1}{2}GC$

$= \frac{1}{2}(AC-AB)$.

$AE = AB+\frac{1}{2}(AC-AB)$

$= \frac{1}{2}(AC+AB)$.

II. *Solution by Murray J. Leventhal, New York City.*

Draw $DF \perp AC$. If $\angle DBA$ is acute, E lies between A and B, and F on AC produced. From the hypothesis, it is easily shown that triangles AED and AFD are congruent, and DE = DF. Therefore, the triangles BED and CFD are congruent. $\therefore AE = AF$ and $BE = CF$. $\therefore AB+AC = AE+AF = 2AE$. $\therefore AE = \frac{1}{2}(AB+AC)$. $\therefore BE = AB-AE = AB-\frac{1}{2}(AB+AC) = \frac{1}{2}(AB-AC)$.

If $\angle DBA$ is obtuse, then $\angle DCA$ is acute, and by a change of signs and an interchange of letters, the proof still follows.

III. *Solution by Gertrude Buck, Adrian, Mich.*

Given $\triangle ABC$ inscribed in a circle, D the middle point of arc CB, and $DE \perp AB$, to prove $AE = \frac{1}{2}(AB+AC)$ and $BE = \frac{1}{2}(AB-AC)$.

Draw AD, CD, DB, and $CF \perp AD$.

$$\overline{DB}^2 = \overline{AD}^2+\overline{AB}^2-2AB\times AE \qquad (1)$$

$$\overline{CD}^2 = \overline{AD}^2+\overline{AC}^2-2AD\times AF. \qquad (2)$$

Since CD = BD,

$$\overline{AD}^2+\overline{AB}^2-2AB\times AE = \overline{AD}^2+\overline{AC}^2-2AD\times AF. \quad (3)$$

Since $\angle CAD = \angle DAB$, $\triangle ACF \sim \triangle ADE$, and $AD\times AF = AC\times AE$.

Substituting in (3) and simplifying, $\overline{AB}^2-\overline{AC}^2 = 2AE(AB-AC)$, whence $AB+AC = 2AE$ and $AE = \frac{1}{2}(AB+AC)$. (4)

But $AE = AB-BE$, then $BE = \frac{1}{2}(AB-AC)$. (5)

IV. *Solution by R. M. Mathews, Riverside, Cal.*

On AB take AF = AC. Draw DC, DA, DF, DB.

$\triangle AFD \cong \triangle ACD$.

$\therefore FD = DC = DB$, and $\triangle BDF$ is isosceles.

Then DE, the altitude, bisects its base, BF.

$\therefore AE = \frac{1}{2}(AB+AC)$

$BE = \frac{1}{2}(AB-AC)$.

This construction has been made the basis for a proof of the law of tangents; see SCHOOL SCIENCE AND MATHEMATICS, XV, *p. 801*.

558. *Proposed by Murray J. Leventhal, New York City.*

From a given point without a triangle to draw a line bisecting the triangle.

I. *Solution by Philomathe, Montreal, Canada.*

Given the triangle ABC and the point P. Draw $PH \perp AB$, $PD \perp BC$. Let $BD = a$ and $PH = h$. To determine the required line PFE, let $DE = x$.

Now, if $2k^2$ represents the area of ABC, we have from similar triangles EBF, EDP,

$$2k^2/hx = (x-a)^2/x^2, \text{ or } x[2(k^2/h+a)-x] = a^2.$$

Hence, to find x, we have simply to construct a rectangle, knowing its area a^2 and the sum of its sides, $2(k^2/h+a)$, a well-known construction. Knowing DE, the line PFE is determined.

Note: These operations can be made on the figure.

II. *Solution by W. W. Gorsline, Crane Tech., Chicago, Ill.*

Given triangle ABC and point P. Required to draw a line from P bisecting the triangle ABC.

Construction:

Through P draw YX parallel to CB, cutting AC and AB produced in Y and X, respectively. Draw a median YR to the side AX, and YZ parallel to PR. Connect ZP, cutting CB at D, and this is the required line.

Proof: $\triangle ARY = \triangle RYX$,

$\triangle PZR = \triangle RYP$.

$\therefore ZPX = \frac{1}{2}\triangle AYX$.

Hence, PZ bisects $\triangle AXY$.

Triangles ZDB and ZPX are similar, and AZDC and AZPY are similar.

Therefore, CB and YX are parallel.

$ZBD/ZXP = ZD^2/ZP^2 = AZDC/AZPY$;

$ZBD/AZDC = ZPX/AZPY = 1/1$. (ZPX = AZPY.)

Therefore, ZBD = AZDC.

$\therefore$ ZP bisects $\triangle ABC$.

559. *Proposed by N. P. Pandya, Sojitra, B. B. & C. I. Ry., India.*

Construct a triangle, having given a side, an angle adjacent to it, and the difference of the medians through its extremities.

Solution by Nelson L. Roray, Metuchen, N. J.

Let $\angle B$ = the given angle, a = the given side, d = difference of medians.

Then we have:

$$m_c = \tfrac{1}{2}\sqrt{2(a^2+b^2)-c^2}.$$

$$m_b = \tfrac{1}{2}\sqrt{2(a^2+c^2)-b^2}.$$

$$b^2 = a^2+c^2-2ac\cos B. \tag{1}$$

$$\tfrac{1}{2}\sqrt{2(a^2+b^2)-c^2}-\tfrac{1}{2}\sqrt{2(a^2+c^2)-b^2} = d. \tag{2}$$

From (1) and (2) we get

$$c = \frac{a\cos B(9a^2-4d^2)\pm\sqrt{a^2\cos^2B(9a^2-4d^2)^2-(9a^2-4d^2)(a^2-4d^2)(9a^2\cos^2B-4d^2)}}{2(9a^2\cos^2B-4d^2)}$$

A value that can be constructed. Hence the triangle is determined (two sides and angle they form).

560. *Proposed by I. N. Warner, Plattesville, Wis.*

Show that the following construction does, or does not, give a regular pentagon.

To a given side AB construct RP perpendicular to its mid-point, R, and equal to AB. Draw AP and extend it to S, making PS = AR. With A as center and AS as radius draw an arc cutting RP extended, at D. A, B, and D are three of the required vertices, and AB a given side, so that C and E are easily determined by using the compasses. Then is ABCDE a regular pentagon?

I. *Solution by R. M. Mathews, Polytechnic High School, Riverside, Cal.*

$AD = AP+PS = \sqrt{5}AR^2+AR = \tfrac{1}{2}AB(\sqrt{5}+1)$.

Thus the sides of the isosceles triangle ABD are proportional to

$$(\sqrt{5}+1)/2 : (\sqrt{5}+1)/2 : 1.$$

Now, the sides of a triangle bounded by two radii and a side of a regular inscribed decagon are proportional to

$$1 : 1 : (\sqrt{5}-1)/2.$$

These two sets of ratios are equal. $\angle ADB = 36°$, and the construction gives a regular pentagon.

II. *Solution by Philomathe, Montreal, Canada.*

In a circle whose radius is r the side of a regular pentagon is $r/2\sqrt{10-2\sqrt{5}}$, and the line corresponding to AD in the figure (called in French the side of the "pentagone étoilé) is $r/2\sqrt{10+2\sqrt{5}}$. The ratio of the two lines is $\sqrt{10+2\sqrt{5}} : \sqrt{10-2\sqrt{5}}$ or $(\sqrt{5}+1) : 2$. Now, in the figure, let $AB = a$, then $AD = (\sqrt{5}+1)a/2$, hence $AD : AB = (\sqrt{5}+1) : 2$. Therefore, A, B, D are three vertices of a regular pentagon.

III. *Solution by Nelson L. Roray, Metuchen, N. J.*

Let $AB = a$, then $AS = a(\sqrt{5}+1)/2$. In triangle ADE, $AD = a(\sqrt{5}+1)/2$, $DE = a$ and $EA = a$. $\cos E = (1-\sqrt{5})/4$, $\therefore E = 108°$. $\therefore C = 108°$. $\angle EAD = 36°$. In $\triangle DAR$, $\cos\angle DAR = (\sqrt{5}-1)/4 = \sin 18°$. $\therefore DAR = 72°$ and $\angle A = 72°+36° = 108°$, and ABCDE is a regular pentagon.

IV. *Solution by C. E. Githens, Supt. of Schools, Wheeling, W. Va.*

Let circle with radius and center A be intersected by line AB at T and S', A lying between T and B. Let $AB = 2a$.

Then $AS = a+a\sqrt{5} = AS'$. $(RS')(RT) = (DR)^2$.

$(a\sqrt{5})(a\sqrt{5}+2a) = DR = a\sqrt{5+2\sqrt{5}}$.

Tangent $RDB = a : a\sqrt{5+2\sqrt{5}} = 1 : \sqrt{5+2\sqrt{5}} = \tan 18°$.

$\angle ADB = 36°$ and arc $AB = 72°$. $\therefore AB$ is side of pentagon.

As arcs AD and BD are equal, bisecting each would produce the other extremities of the chords each equal to AB.

CREDIT FOR SOLUTIONS.

531. R. Sundaram Aiyar.

551. C. E. Flanagan. (Omitted by mistake in last issue.)

552. Nelson L. Roray, R. M. Mathews.

554. C. E. Flanagan.

556. Ruth A. David, one incorrect solution.

557. E. L. Brown, Gertrude Buck, C. E. Githens, Murray J. Leventhal, R. M. Mathews, Ola McClusky, R. T. McGregor, Philomathe, Nelson L. Roray, Arnold S. Worfolk.

558. E. L. Brown, C. E. Githens, W. W. Gorsline, Murray J. Leventhal, R. M. Mathews, Philomathe, Nelson L. Roray.

559. Philomathe, Nelson L. Roray.

560. C. E. Githens, W. W. Gorsline, R. M. Mathews, Philomathe, Nelson L. Roray.

PROBLEMS FOR SOLUTION.

Algebra.

571. *Proposed by Harold M. Lufkin, St. Andrew's School, St. Andrew's, Tenn.*

Solve:

$$2\sqrt{2x+2} + \sqrt{2x+1} = \frac{\sqrt{12x+4}}{\sqrt{8x+8}}$$

Geometry.

572. *Proposed by Takeshi Omachi, Sendai, Japan.*

Catalan's Theorem: In a quadrilateral ABCD, if the sides AB and CD are equal to each other, the straight line MN passing through the middle points M and N of the sides BC and AD will equally incline to the sides AB and CD.

573. *Proposed by Clifford N. Mills, Brookings, S. Dak.*

From one of the angles of a rectangle a perpendicular is drawn to its diagonal, and from the point of their intersection straight lines are drawn perpendicular to the sides which contain the opposite angle. Show that if a and b be the lengths of the perpendiculars last drawn, and c the diagonal of the rectangle,

$$a^{\frac{2}{3}} + b^{\frac{2}{3}} = c^{\frac{2}{3}}.$$

574. *Proposed by N. P. Pandya, Sojitra, B. B. & C. I. Ry., India.*

Construct a triangle ABC, having given the distances of its incentre, circumcentre, and orthocentre.

575. *Selected.*

Prove this theorem from Wentworth-Smith's *Solid Geometry* (Exercises on Book VI) by means of earlier theorems.

If the face angle AVB of the trihedral angle V-ABC is bisected by the line VD, the angle CVD is less than, equal to, or greater than half the sum of the angles AVC and BVC according as CVD is less than, equal to, or greater than a right angle.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

University School, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Science Tests.

Tests on Heat—H1 to H14 inclusive—together with tests on Electricity —E1 and E2—have now (May 1, 1918) been mailed to all the correspondents requesting them. Probably before the June number of SCHOOL SCIENCE AND MATHEMATICS appears, a complete set on Electricity, Sound, and Light will have been sent out. The printing and preliminary testing of this material has proved a very serious task. These tests have attacked only the *numerical problem* in physics. The results, however, are pointing the way to the testing of other forms of ability.

The time required for the physics tests has prevented the work preliminary to printing chemistry tests. It is, however, anticipated that material can be mailed early next fall on chemistry. *Send in your names now.*

Please report your results on physics at once, even if you do regard your work as incomplete or unsatisfactory. Schools will be referred to by number, not by name, except as special permission is requested.

Examination Papers.

Now, address an envelope to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio. Insert your second semester examinations for the Editor of this department. They will be of interest and value to others.

QUESTIONS AND PROBLEMS FOR SOLUTION.

305. *What do you think of this test on heat submitted by Miss Annie Cloyd, Sewickley, Pa.? Thirty-three pupils averaged 85 per cent. Is it too easy?*

1. The mechanical equivalent of heat is.....
2. It was worked out by.....
3. His work was important because it proved.....
4. A calorie of heat is.....
5. Specific heat is.....
6. Specific heat is found by the.....
7. Upon what principle is this method based?
8. The heat of fusion is.....

Its value for water is.....

9. To vaporize one gram of water it takes.....
10. The boiling point of any substance is the temperature at which

.....

11. Give two instances where water boils at a lower degree than 100°.
12. Explain fully why a mixture of ice and salt freezes cream.

306. *Submitted by W. F. Roecker, Boys' Technical High School, Milwaukee, Wis.*

Solve 10 questions from this list. How long did it take you? Is the examination too long or too short?

TRADE PHYSICS: MECHANICS AND HEAT.

1. A differential pulley has wheels of 6 inch and 5 3-4 inch diameter, respectively. (*a*) What is its mechanical advantage? (*b*) If it requires a force of 500 pounds to lift the front end of an automobile, how great a force must be exerted on the chain of this pulley to raise that part of the automobile, the efficiency being 30% under this load?

2. An automobile tire contains 1500 cubic inches of air at 12° C., and a pressure of 90 pounds per square inch. Driving the car causes the air in the tire to be heated to 33° C. What is the pressure, if the air in the tire now has a volume of 1530 cubic inches?

3. The ice man is supposed to deliver 25 pounds of ice daily. He delivers a piece, $12 \times 10 \times 8$ inches. Are you ahead or short, and how much? Ice has a density of .92 grams per cubic centimeter.

4. The coefficient of linear expansion of brass is .0000187 per Centigrade degree. If the melting temperature of brass is 1692° F., how much must be allowed for shrinkage in making patterns for brass castings?

5. (*a*) The coefficient of friction between the driving wheels of a locomotive and the rails is .25. How much must the locomotive weigh in order to exert a pull of 20 tons? (*b*) How may friction be reduced?

6. (*a*) Define elastic limit, breaking strength, tensile strength. (*b*) A beam 4 inches wide and 2 inches thick, when standing on edge bends .1 inch per thousand pounds. How much per thousand would it bend when laid flat side down?

7. Explain the action of the fever thermometer; of the electric pyrometer.

8. Discuss the advantages and disadvantages of the hot water heating system.

9. Explain how the thermostat controls the temperature of a room in this school. Diagram.

10. Show by diagram how the gas meter measures the gas consumed. If you should receive a monthly gas bill for $10.35, what checks would you make to determine why the bill is so large?

11. If the water pressure in a city water main is 50 pounds per square inch, and the diameter of the plunger of the elevator is 10 inches, how heavy a load can the elevator lift, friction loss being 25 per cent?

12. The area of the piston of a steam engine is 120 square inches, its stroke is 2 feet, the "mean effective pressure" is 50 pounds per square inch, and it makes 150 revolutions per minute. What is the "indicated horse power"? If the brake test shows that the engine delivers 90 horse power, what is its mechanical efficiency?

SOLUTIONS AND ANSWERS.

287. *Proposed by O. L. Brauer, Selma, Cal.*

To what extent is crystal formation dependent on water of crystallization?

An examination of a few pages of Van Nostrand's *Chemical Annual* showed of 54 inorganic substances for which a crystalline form was given, 22 crystallize with water, 32 crystallize without. A complete tabulation of formulas and form would answer the question in full.

Kahlenberg (*Outlines of Chemistry*, p. 156) calls attention to the fact that, "with water copper sulphate forms the compound $CuSO_4$, $5H_2O$ . . . . . Similarly, with dry ammonia copper sulphate forms the compound $CuSO_4$, $5NH_3$."

295. *Proposed by S. R. Powers, Minneapolis, Minn.*

"We find, as we continue to dilute an electrolyte, that the molecular conductivity increases up to a certain point beyond which it does not change. This might be expected for, at a certain dilution, *all* the molecules are dissociated and a further dilution causes no further dissociation." [Quoted from a recent high school text.]

Is this true? Is 100% dissociation attained?

100% dissociation is not attained. Consult Walker's *Physical Chemistry* (The Macmillan Company).

301. *Proposed by C. H. Prescott, University School, Cleveland.*

How many calories of heat must be supplied to melt 10 grams of ice?

Is the answer the same when British Thermal Units (B. T. U.) are used? Explain.

Answer by C. Arthur Smith, High School East, Salt Lake City, Utah.

$10 \times 80 = 800$, the number of calories required to melt the ice.

The B. T. U. is defined as the heat required to raise 1 pound of water 1° F.

1 pound is equivalent to 454 grams.

1° F. is equivalent to 5/9° C.

$454 \times (5/9) = 252$ cal.

Therefore, 1 B. T. U. is equivalent to 252 cal.

$800 + 252 = 3.17$ B. T. U. of heat required to melt the ice.

254. *Correction by K. H. Fussler is acknowledged.*

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, for March; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $5.00 per year, 60 cents a copy:* "A Demonstration of Photosynthesis," W. J. V. Osterhout; "The Flavones of Rhus," Chas. E. Sando and H. H. Bartlett; "Conservatism and Variability in the Seedling of Dicotyledons," Edmund W. Sinnott; "Noteworthy Lejeuneae from Florida," Alexander W. Evans.

Geographical Review, for April; *Broadway at 156th Street, New York City; $5.00 per year, 50 cents a copy:* "Albania and the Albanians," (one map, eight photos), H. C. Woods; "American Explorers of Africa" (one autograph, two photos), Edwin S. Balch; "The Development of the Philippine Islands" (five photos), H. J. Waters; "The Pampa of Argentina" (nine maps, two diagrams, five photos), Walter S. Tower; "The Influence of Geographical Environment upon Religious Beliefs," R. H. Whitbeck.

Journal of Geography, for April; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Montana," Grant E. Finch; "The Weather Factor in the Great War: VIII," Robert De C. Ward; "Geography Made Real by Field Study," Jennie Hall; "Some Results of the Location of Australia," S. S. Visher; "The Origin of Petroleum Pools," Edward Steidtmann.

Literary Digest, for April 6; *New York City; $3.00 per year, 10 cents a copy:* "The Battle That May Decide the War: Shipyards Gaining on the 'U'-Boat"; "Our First Year in the War"; for April 13: "The Battle of Picardy Just Beginning"; for April 20: "The Supreme Call to Arms"; for April 27: "Why We Have the Whip Hand: To Make Wages Keep Step with the Cost of Living."

Nature Study Review, for April; *Ithaca, N. Y.; $1.00 per year, 15 cents a copy:* "A Fish Pond for the Farm Boy," J. G. Needham; "The Physiognomy of Fishes," R. W. Shufeldt; "The Weepeckets," Elizabeth D. Wuist; "The Salmon," Jay R. Traver; "A Method of Fish Study for Beginners"; "War and Nature—An Appeal," John Price Jones; "The Proper Treatment for Goldfish—Humane Education."

Photo-Era, for April; *Boston, Mass.; $2.00 per year, 20 cents a copy:* "A Simple Method of Photography," Alfred W. Cutting; "Tanks for the Photography of Objects in Fluids," *British Journal;* "How to Make an Inexpensive Weighing Scale," H. L. Peterson; "Sharp or Diffused?" *Photography;* "Flashlight Work for the Amateur," W. R. Bradford; "Photographs in the Home," *Photography;* "Orthochromatic Plates in the Studio," James Cooper.

Popular Astronomy, for May; *Northfield, Minn.; $3.50 per year:* "The Total Eclipse of the Sun, June 8, 1918" (with Plates XIII and XIV), H. C. Wilson; "Useful Observations at Observatories and Laboratories Outside the Zone of Totality, June 8, 1918," Edwin B. Frost; "The Sun's Eclipse of June 8, 1918: Question," John F. Lanneau; "A Contribution to the Eclipse of June 8, 1918," Joseph Ubach, S. J.; "Contacts and Duration Times for the Solar Eclipse," Martha Mengel; "Duration Times for the Total Solar Eclipse," Francis Ruth Hole; "The Recurrences of Solar Eclipses," F. E. Seagrave; "Report on Mars No. 20," William H. Pickering; "What Was the Star of Bethlehem? (Continued)," Stansbury Hagar; "From Universe to Cosmos," Charles N. Holmes.

Popular Science, for May; *New York City; $1.50 per year, 15 cents a copy:* "Trapping Salmon in the Far North," Christian Leden; "The Richest Food in the World," Hudson Maxim; "Our War Sugar Bowl," John W. Harrington; "Wind, Weather, and the Airman: Cooking Your Meals While You Drive," Albert Marple; "Letting Gasoline Do It: Grading Machine Does Work of 125 Men"; "Homes for War Workers," John W. Harrington; and scores of other splendid articles. Send for this issue.

Review of Reviews, for April; *New York City; $3.00 per year, 25 cents a copy:* "Russia's Mutilation—Germany Unmasked," Frank H. Simonds; "Our Navy in the War," Hon. Josephus Daniels, Secretary of the Navy; "Motor Trucks to the Rescue," Harry W. Perry; "The National Non-

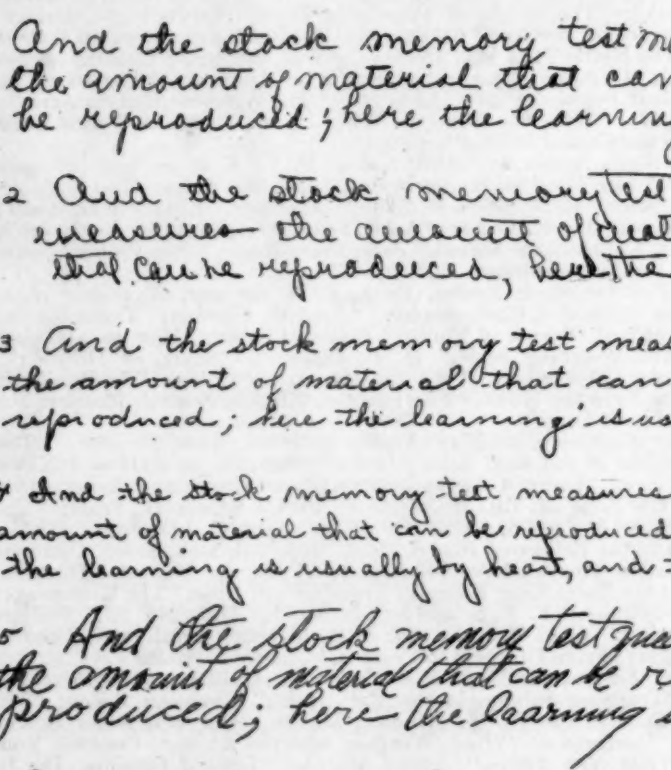
partisan League," John Thompson; "The Glorious City of Bagdad," John P. Peters; "Russia and Japan," K. K. Kawakami.

School Review, for April; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "A Statistical Study of the Junior High School from the Point of View of Enrollment," Paul C. Stetson; "With Eyes They See Not," Mary Jenness; "Semester Reorganization and Program-Making in the Central High School of St. Paul, Minnesota," A. G. Meier; "Supervised Study in High School," G. W. Willett; "Extra Curricular Activities in High Schools," Hazel M. Harwood; "The Curriculum of the Modern Six-Year Secondary School," L. C. Ward.

School World, for April; *Macmillan Company, London, Eng.; 7s. 6d. per year:* "The Arithmetic of Citizenship, II," T. P. Nunn; "The Use of Books in American Schools," Hilda J. Hartle; "Some Thoughts on Science Teaching in Schools," W. A. Herdman; "Science in Secondary Schools: British Association Report."

ERRATUM.

On page 408 of the May issue the half-tone shown below was inadvertently omitted. The six lines immediately under the graph on page 409 should have been omitted as they appear on the reproduction here given.


1 And the stock memory test measures the amount of material that can be reproduced; here the learning is
2 And the stock memory test measures the amount of material that can be reproduced, here the
3 And the stock memory test measures the amount of material that can be reproduced; here the learning is usually
4 And the stock memory test measures the amount of material that can be reproduced: here the learning is usually by heart, and the
5 And the stock memory test measures the amount of material that can be reproduced; here the learning is
Grade in %
1
2
3
4
5
Grade in terms
Excellent
Good
Fair
Passed
Failure

SOUTHERN CALIFORNIA SCIENCE AND MATHEMATICS ASSOCIATION.

The twentieth regular semiannual meeting was held at the Los Angeles High School, April 29, 1918, the following program being given:

GENERAL MORNING SESSION.

(About 110 present.)

Demonstration of scientific films.

Address of welcome—Principal Housh.

Music.

Demonstration of visual education material—H. S. Upjohn, Superintendent of Visual Education for Los Angeles County.

"The Application of Psychology to the Teaching of Science"—Address by Dr. A. Sutherland, Ph. D., Los Angeles City Schools, Psychologist.

"The Development of the Airplane"—Address by Major B. M. Woods, Ph. D., Department of Applied Mathematics, University of California, President of the Academic Board of Military Aeronautics.

Business meeting.

AFTERNOON SECTION MEETINGS.

Mathematics Section.

"Mathematical Notes for an Enlisted Man, Coast Artillery"—Address by Mr. Hugh C. Willett, Professor of Mathematics, University of Southern California.

"Experiences and Methods in Teaching Mathematics and Engineering to Men Preparing to Be Officers in the U. S. Navy"—Address by Lieutenant H. E. Carse, U. S. N. R. F.

Earth Science Section.

Excursion to the La Brea fossil pits, under guidance of Dr. J. Z. Gilbert, one of the discoverers and early workers of the Pits.

Physics-Chemistry Section.

"New Ways of Doing Old Things"—Demonstrations by various members of the section.

Visits to the laboratories of the new Los Angeles High School.

Biology Section.

"The Kelp Industry and Munitions Manufacture"—Address by Mr. N. C. Crandall, Manager of the University of California Marine Biological Station at La Jolla, Federal Fish Commissioner for the South Pacific Coast.

In the course of their talks, Dr. Woods, Professor Willett, and Lieutenant Carse laid emphasis upon the fact that recruits are needed who know how to study effectively, and they urged the high school teachers present to require of their pupils concentration, thoroughness, and speed in studying.

The demonstration of materials from the Los Angeles County Visual Education Bureau included films and sets of scientific slides (about thirty slides in a set, with notes) on such topics as astronomy, American birds, anatomy, tuberculosis and housing studies, aeroplane studies, California tree studies, forestry, concrete, volcanoes, and earthquakes, story of the ice age, animals of the past, X-ray studies, subway and tunnel construction, submarine, industries such as rubber, glass, fisheries, leather, skyscrapers, cotton, silk, iron, and steel, brick, coal mining, and meat packing. The majority of the sets are prepared in the County Bureau laboratory, which is also the centre for exchange of films, industrial exhibits, maps and charts, etc., etc.

At the business meeting the Association voted to buy a Liberty Bond.

HARRIET S. KING,
Secretary.

BOOKS RECEIVED

Laboratory Manual to Accompany Foundations of Chemistry, by Arthur A. Blanchard, Massachusetts Institute of Technology, and Frank B. Wade, Shortridge High School, Indianapolis. Pages vi+203. 19×24 cm. Paper. Loose leaf. 1917. 52 cents. American Book Company, Chicago.

A Textbook of Precious Stones—For Jewelers and Gem-Loving Public, by Frank B. Wade, Shortridge High School, Indianapolis. Pages xii +318. 14×20.5 cm. Cloth. 1918. $2.00. G. P. Putnam's Sons, New York City.

The Third and Fourth Generation, by Elliot R. Downing, University of Chicago. Pages xi+164. 13.5×19.5 cm. Cloth. 1918. $1.00. University of Chicago Press, Chicago.

The Laboratory Study of Chemistry, by Herbert R. Smith, Lake View High School, Chicago, and Harry Mess, Senn High School, Chicago. Pages xiv+256. 21×25 cm. Paper. 1918. Henry Holt & Company, New York City.

Advanced Algebra, by W. C. Brenke, University of Nebraska. Pages vii+196. 14×21 cm. Cloth. 1917. $1.25. The Century Company, New York City.

Elements of Trigonometry, with Tables, by W. C. Brenke, University of Nebraska. Pages vi+121+39. 14×21 cm. Cloth. 1917. $1.25. The Century Company, New York City.

Carnegie Foundation for the Advancement of Teaching, Twelfth Annual Report, by the President and Treasurer. Pages vi+154. 18.5×25 cm. Paper. 1917. 576 Fifth Ave., New York City.

Principles of Bookkeeping, Introductory Course, by George W. Miner and Fayette Elwell. Pages viii+556+xx. 15.5×25.5 cm. Cloth. 1918. $1.30. Ginn & Company, Boston.

Addresses and Proceedings—Fifty-fifth Annual Meeting, National Education Society. Pages ix+864. 16×23.5 cm. Cloth. 1917. Published by the Association, Washington, D. C.

Carnegie Foundation for the Advancement of Teaching, Federal Aid for Vocational Education, by I. L. Kandel. Pages vi+127. 18.5×25.5 cm. Paper. 1917. 576 Fifth Ave., New York City.

Junior High School Mathematics, by William L. Vosburgh, Boston Normal School, and Frederick W. Gentleman, Mechanical Arts High School, Boston. Pages x+212. 13×19 cm. Cloth. 1918. 90 cents. The Macmillan Company, New York.

Infinitesimal Calculus, by F. S. Carey, University of Liverpool. Pages x+352+iv. 14.5×22 cm. Cloth. 1918. $3.00. Longmans, Green & Company, New York.

The Vocational Education of Girls and Women, by Albert H. Leake, Inspector of Manual Training and Household Arts, Ontario, Can. Pages xix+430. 13×19.5 cm. Cloth. 1918. $1.60. The Macmillan Company, New York City.

The Teaching of Agriculture, by Aretas W. Nolan, University of Illinois, and Agricultural Editor of SCHOOL SCIENCE AND MATHEMATICS. Pages ix+277. 13×19 cm. Cloth. 1918. $1.30. Houghton, Mifflin Company, New York City.

The Botany of Crop Plants, by Wilfred W. Robbins. Pages xix+681. 13.5×19.5 cm. Cloth. 1917. $2.00. Blakiston's Son & Co., Philadelphia.

Textbook of Mycology and Plant Pathology, by John W. Harshberger. Pages xiii+779. 13.5×19.5 cm. Cloth. 1917. $3.00. Blakiston's Son & Company, Philadelphia.

Plant Physiology, by Vladimir I. Palladin, University of Petrograd. Translation edited by B. E. Livingston. Pages xxv+320. 15.5×23.5 cm. Cloth. 1918. Blakiston's Son & Company, Philadelphia.

Library Books for High Schools, compiled by Martha Wilson, Supervisor of School Libraries, Minn. 175 pages. 14.5×23 cm. Paper. 1918. 15 cents.

Predetermination of Prices, by Frederic A. Parkhurst. Pages viii+96. 15×23 cm. Cloth. 1916. $1.25 net. John Wiley & Sons, New York City.

The Organization of Thought, by A. N. Whitehead, Trinity College, Cambridge. Pages vii+228. 14.5×22.5 cm. Cloth. 1917. $2.00 net. J. B. Lippincott Company, Philadelphia.

Plane and Spherical Trigonometry, by Leonard M. Passano, Massachusetts Institute of Technology. Pages xv+139. Cloth. 1918. $1.25. The Macmillan Company, New York.

Essentials of Physics for College Students, by Daniel W. Hering, New York University. Pages x+367+31. 15×22.5 cm. Cloth. 1918. $1.75 net. D. Van Nostrand Company, New York City.

Transactions of the Illinois Academy of Science, Tenth Annual Meeting, Knox College, Galesburg, Ill., February 23-24, 1917. 345 pages. 15×23 cm. Paper. 1917. Published by the State.

Language Reform and the Progress of English Peoples, by Dr. Jos. V. Collins, State Normal School, Stevens Point, Wis.

Scientific Method in the Reconstruction of Ninth-Grade Mathematics, by Harold O. Rugg, University of Chicago, and John R. Clark, Parker High School, Chicago. Pages v+189. 17×24 cm. Paper. 1918. $1.00 net. University of Chicago Press.

BOOK REVIEWS.

The Carnegie Foundation for the Advancement of Teaching. Federal Aid for Vocational Education, Y. I. L. Kandel, Columbia University, Bulletin No. 10. Pages vii+127. 18.5×25 cm. Paper. 1917. Also *Twelfth Annual Report, by the President and Treasurer.* Pages vi+154. 18.5×25 cm. Paper. 1917. 576 Fifth Ave., New York City.

The general public knows very little about the efforts the Government has taken to assist in vocational education. The author gives a very complete history of the original agricultural college land grant of 1862, fathered by Senator Morrill of Vermont, and the annual grant of 1890 is splendidly discussed, as is also the grant of 1907. The relation of the Government to the many phases of vocational education is presented in a very thorough and comprehensive manner. The book is a valuable addition to the literature of the history of education.

The *Twelfth Annual Report* gives in some detail the financial condition of the Foundation. Some limitations in administration of its funds have caused the Trustees to consider a plan of insurance and annuities. The subject of pensions in general is pretty thoroughly discussed. Several reports of educational inquiry are given. Part V is devoted to the report on necrology, the treasurer's report is presented, and there is a complete index.

Copies of these reports may be had by addressing the Foundation.

C. H. S.

A Textbook of Botany for Colleges, by William F. Ganong. 595 pages. 13.5×20 cm. Cloth. 1916. $2.00. The Macmillan Company, New York.

An excellent general textbook of botany for college use, or for high school reference. It is published in two parts, bound separately. The

first part is concerned with the general morphology of leaves, stems, roots, flowers, fruits, and seeds. The second part, about one-third of the book, takes up the morphology of the plant groups in systematic fashion, and a chapter on the ecological classification of plants is added.

The outstanding features of the book appear to be these. It is a truly general botany, constituting a real introduction to the science. It is written from the point of view of the students who pursue the subject as a part of their cultural training rather than as a preparation for a professional botanical career. Thus it "gives more attention to the large and visible aspects of plant nature than to the minute and obscure." The physiology of plants is very intimately connected with their morphology, and physiology is given a prominence that is unusual in introductory textbooks. The book is written with careful regard to the psychology of the college student, and the literary style is most pleasing.

The author has long been known for his interest in the pedagogics of botany, and has possibly given more attention to the psychology of teaching botany in college than has any other contemporary botanist. The present work is worthy of its author in every way. W. L. E.

The Third and Fourth Generation, by Elliot R. Downing, University of Chicago. Pages xi+164. 13.5×19.5 cm. Cloth. 1918. $1.00. University of Chicago Press, Chicago.

This splendid and valuable book has come from the pen of one of our most careful students in nature study as well as in the science of biology. The author has devoted much time in the last fifteen years to a study of the questions discussed in his little book. The volume is not by any means complete, but it is thoroughly up to date, containing much of the matter on the subject of heredity which has been discovered and studied in the last decade. It is not intended to be an exhaustive scientific treatise for the university man, but it is intended primarily for young folk and laymen. The diction is splendid, and the style is interesting, so that the young reader will be attracted at once. There are ten chapters. The type is clear, and the mechanical part of the book is of the highest order. At the end of each chapter there is a set of questions bearing upon the matter treated in that chapter. There is a bibliography of two pages, and a very complete index of four pages. C. H. S.

Education for the Needs of Life, by Irving E. Miller. Pages vii+353. 13×19 cm. Cloth. 1917. $1.25. The Macmillan Company, New York City.

This is the correct title for this particular book, and if all people who wish to make the most of the education which they can get from books especially, could read and study this particular text, they would be better able to guide their future study into the proper channels for making their lives most successful. The fundamental aim of the book is to discuss and interpret education. Although education is a phase of the life process, this book interprets to the reader precisely what education is and applies it to one's development.

There are only six chapters, under the following heads: "The Biological Point of View in Education" (forty-eight pages); "The Meaning and Aim of Education" (thirty-three pages); "The Child" (seventy-four pages); "The Curriculum" (forty-four pages); "The Principles of Method" (ninety-seven pages); "The Teacher" (fifty pages). The diction is splendid, and the volume is written in such a fascinating manner that the average student cannot help but become interested in its reading. The type is large, and it is printed on uncalendered paper, thus reducing the direct reflection to a minimum. Each chapter closes with a summary, together with a list of books for supplementary reading. There is an index of five pages. Mechanically, the book is well made. C. H. S.

Problems in General Physics for College Courses, by Morton Masius, Worcester Polytechnic Institute. Pages vi+90. 13.5×21 cm. Cloth. 1917. 90 cents. Blakiston's Son & Company, Philadelphia.

This is a little book containing one thousand problems in general physics, covering all phases of the subject as usually taught in college and university. The book will be found extremely helpful to instructors in this subject, either for examination or for review. The questions are of such a general nature that they require the student to think before he can answer them correctly. C. H. S.

The Natural History of Chautauqua, by Vaughan MacCaughey of the Chautauqua Summer School. 135 pages. 14×21 cm. Cloth. 1917. B. H. Huebsch, New York City.

This small volume will be hailed with delight by the thousands of people who have paid a pilgrimage to the original Chautauqua in western New York. The book is an outgrowth of ten years of natural history study and teaching in the Chautauqua Summer School. It is hoped that the volume will lead many to have an increased desire for nature study work. It is full of valuable information and will teach the reader how to study nature in the place where he may happen to live. C. H. S.

Chemical Apparatus and Chemicals; Complete Laboratory Equipment for Every Grade of High School, College, and Technical Laboratory; Chemical Catalog No. 94, is the title of a new catalog just put out by the Cambridge Botanical Supply Company.

It is a very attractive book of 176 pages, packed full of meat, and everything that a chemical laboratory needs. Besides the usual index there is on page 4 a table of contents that makes the book very usable. In addition to the regular lists and prices of apparatus and chemicals, it has the following special features: an up-to-date table of international atomic weights, a list of nearly two hundred chemistry lantern slides, lists of apparatus for four of the best known laboratory manuals, a minimum list of general science apparatus selected by the Massachusetts General Science Committee, and very complete lists of Alundum ware and Pyrex glassware.

The book is mechanically well made, printed on a high grade of paper, and reflects credit on this old and reliable house. Every chemistry teacher should have a copy on his desk for reference and use when making out his orders. C. M. T.

A Short History of Science, by W. T. Sedgwick, Biology, and H. W. Tyler, Mathematics, Massachusetts Institute of Technology. Pages xv+474. 15×22 cm. Cloth. 1917. $2.50. The Macmillan Company, New York City.

This book is the outgrowth of a course of lectures given by the authors in the Massachusetts Institute of Technology during the last several years. Of course there are many volumes on the history of science in print, but in most cases they have been written for specialists in particular lines of work. This book is a departure then from most volumes in print, by virtue of the fact that it appeals more especially to the student and general reader, and tells him what the influence of scientific method is and has been in the last one hundred years in molding and directing human events. The authors surely have brought together a fund of valuable information and compressed it into a small space in this one volume. It is splendidly written, and is a valuable addition to historical literature in the field of science and mathematics. There are seventeen chapters and several appendices. There is a very complete index of six pages. At the end of each chapter is given a list of books for reference reading. Every student of history should have this volume in his library. It deserves a wide circulation. C. H. S.

A Textbook of Precious Stones for Jewelers and the Gem-Loving Public, by Frank B. Wade, Shortridge High School, Indianapolis, Ind. Pages xiii+318. 14×20.5 cm. Cloth. 1918. $2.00. G. P. Putnam's Sons, New York City.

This book has been in the process of preparation for years by this well-known student of precious stones. He has applied his splendid knowledge of chemistry in a very practical way by bringing it to bear upon the nature of precious stones of almost every kind. He has endeavored to present in the most fundamental way the methods which are used in identifying gems. The book will be found to be helpful not only to the dealer in jewels, but especially to the purchaser of the same. If the latter individual has a thorough knowledge of the nature of precious stones, he will not be cajoled into purchasing stones which to the ordinary layman look exactly like the real thing, but which are of little value.

There are thirty chapters in the volume, together with a very complete bibliography. The index, too, is of a nature such that one may find at once without difficulty where various questions are discussed. It is a book which should have an extensive circulation among all people interested in gemology. C. H. S.

Plane and Spherical Trigonometry, by Leonard M. Passano, Associate Professor of Mathematics in the Massachusetts Institute of Technology. Pages vii+141. 13×20 cm. 1918. The Macmillan Company, New York.

This text aims to present trigonometry in such a way as to make it interesting to students approaching some maturity, and to connect the subject not only with the preceding mathematics, but also with the mathematics to follow. Full explanations are given of important principles, but many simple details are left to the work of the student. Positive and negative angles of any magnitude and their trigonometric functions are given at the beginning of the book, and the basic trigonometric identities are derived at once for all angles. The solution of right triangles and related problems are taken up early without the use of logarithms. The number of identities to be memorized is reduced to a minimum. The lists of exercises and problems are numerous and carefully chosen; many of them are taken from analytic geometry and calculus, though no knowledge of these subjects is assumed. Some of the problems have been invented for this book, and all the problems are chosen to show the practical interest and value of trigonometry. H. E. C.

Analytic Geometry, by Edwin S. Crawley and Henry B. Evans, Professors of Mathematics in the University of Pennsylvania. Pages xiv+239. 13×19 cm. 1918. Edwin S. Crawley, University of Pennsylvania.

In compiling this work the authors have endeavored to keep in mind the needs of the average student. As this subject is not easy even for the trained mind to grasp, though it is built on combinations and applications of ideas already familiar, the attempt is made to approach by easy steps so that the student may feel sure of his ground as he advances. Mathematical rigor, however, has been preserved throughout. The examples and problems are good. At the end of each chapter the exercises are divided into two parts—"normal exercises," which are direct applications of the chapter, and "general exercises" for testing the student's grasp of the subject as a whole and of its underlying principles. The chapter on empirical equations gives a very clear exposition of the methods of finding the equation of a curve which satisfies nearly as possible the conditions of the problem. H. E. C.

Commercial Algebra, Book I, by George Wentworth, David Eugene Smith, and William S. Schlauch. Pages v+266. 13.5×19 cm. 1918. $1.12. Ginn & Company, Boston.

For use in the first year of a commercial high school this book offers some excellent work. The use of letters and other symbols, formulas, graphs, and equations are studied in a way to make them useful in business affairs. A large part of the problems are based on business transactions and reveal the advantages of knowing something of algebra. Though much of the formal and nonessential work given in the usual course in algebra is omitted, there is sufficient abstract work to give the necessary drill in handling literal expressions. This book is well worth the attention of teachers in commercial high schools. H. E. C.

Plane Geometry, Revised Edition, by H. E. Slaught, Professor of Mathematics in the University of Chicago, and N. J. Lennes, Professor of Mathematics in the University of Montana. Pages viii+310. 13×19 cm. 1918. Allyn & Bacon, Boston.

The authors and publishers are to be congratulated on the many fine qualities of this revision. It was read with real pleasure as page after page revealed some new and interesting way of presenting the cold facts of geometry. The practical applications to everyday life and the numerous exercises in sight work and experimental geometry disclose to the students the use of geometric principles in constructing buildings, ships, machinery, and the like, and give an excellent approach to the logical demonstration of geometric truths. The simple and direct way of treating areas of polygons and regular polygons is typical of the many improvements that will appeal to teachers. H. E. C.

Laboratory Manual to Accompany Foundations of Chemistry, by A. A. Blanchard, Associate Professor of Chemistry, Massachusetts Institute of Technology, and F. B. Wade, Head of Chemistry Department, Shortridge High School, Indianapolis, Ind. 20x25 cm. Pages, 196. 1918. American Book Company.

This is a new high school laboratory manual, prepared by successful teachers of many years' experience. Although the book is designed to accompany the textbook by the same authors, it can be used with any text. It is arranged on the loose leaf plan, one experiment on each sheet. The book contains ninety-five experiments.

In the table of contents, the experiments are marked in five ways, showing the character of the experiment, whether considered as necessary in the logical development of the course, supplementary, special technical applications, those considered dangerous or too expensive for the average pupil, and demonstration experiments. The subdivisions assist the instructor greatly in laying out his course of laboratory work.

The authors have omitted many of the time-honored stock experiments that are found in all manuals, and substituted others that are more up-to-date and of general practical interest, as well as illustrating chemical principles.

One of the most important features is the use of practical questions in italics at the end of each experiment. These questions make the student think, and serve to retain in his memory as no other way can the important facts observed and the principles illustrated by the experiment.

The laboratory directions are very clear, definite, and understandable by the average high school pupil. A minimum of explanation will be required of the instructor.

The manual reflects great credit on the authors and is one of the best laboratory manuals on the market today. C. M. T.

Science for Beginners, by Delos Fall, Albion College. Pages ix+382. 14×19 cm. Cloth. 1917. The World Book Company, Yonkers on Hudson, New York.

No one is better qualified to prepare a book of this description for use with high school pupils in matters of general science than the author of this splendid book. It covers the whole range of subjects that are usually taught in a course in general science. There are thirty-four chapters in the book. It is written in a manner which will at once secure the attention of the boy and girl. The method of presentation and the very suggestive drawings and cuts are such as to make the book one of the very best which has ever been printed. There are 231 illustrations, most of them new and original. There are numerous exercises scattered throughout the text. The major paragraphs all begin with bold-faced type, which gives the cue to the matter discussed in that paragraph. It is a book that is worthy of an extensive use, and doubtless it will have a wide and ready sale. There is a very complete index appended. C. H. S.

Laboratory Study of Chemistry, by Herbert R. Smith, Lake View High School, Chicago, and Harry M. Mess, Senn High School, Chicago. Pages xiv+256. 21x25 cm. Paper. 1918. Henry Holt & Company, New York City.

Current educational literature contains many articles on "supervised study" and "teaching pupils how to study." For some time teachers of science have contended that laboratory work is one of the best forms of supervised study. Too often, however, laboratory manuals are written to accompany a text in which are found such abstract statements and mature conclusions which might better be developed by the pupil through his laboratory experimentation. The greatest value in laboratory work lies in its training in the method of effective problem solving.

The Laboratory Study of Chemistry will meet the demands of those teachers who believe in the laboratory method of approach in studying chemistry. For those who believe in the textbook method, this manual will furnish "food for thought." The reviewer considers it the best chemistry manual published, for both teacher and pupil, as far as the method of presentation is concerned.

The descriptive, practical, and historical introductions to the experiments arouse the desire of the pupils to undertake the laboratory exercises. These introductions do not, like most texts, present the answers to questions and conclusions of experimentation which the pupils may gain for themselves through reflective thinking on the results of experimental work. They do give the pupil a viewpoint, suggest problems to be solved, and encourage the scientific attitude. Excellent references to supplementary reading material are found with each experiment.

The directions for the pupils' laboratory work are carefully prepared and have been used by the authors with satisfactory results. They are printed on perforated sheets and not numbered. This allows for their use with any textbook and in any order desired. Fundamental experiments are starred. Many optional experiments for the apter pupils are given.

The appendix is particularly valuable. It includes classified lists of books for the chemical library; a table of logarithms; usable tabular material on physical constants, solubility, composition of alloys; an excellent list of reagents and solutions with their formulas and suggestions for preparation of the solutions; etc.

Every teacher of chemistry and teachers of other sciences should examine this valuable contribution to the method of secondary science teaching. C. J. P.

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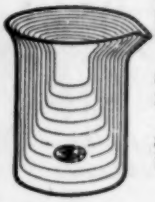

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If, in a moment of forgetfulness, you had left your umbrella or fountain pen, would it be presumptuous to call your attention to it? If you were deliberately casting aside something of whose great value you were not aware, wouldn't it be a matter of duty to call your attention to *that?* In the same spirit we feel that to allow you to drop out of the Central Association, either thoughtlessly or deliberately, without calling your attention to your loss in so doing, would be wrong.

Your subscription to SCHOOL SCIENCE AND MATHEMATICS has expired. The subscription price of this magazine alone is equal to your annual dues in the Association. It is a magazine unique in its field, and we believe is of real value to teachers of science and mathematics. The numbers you have missed will be sent upon receipt of your dues.

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We hope we have made our point that the Association desires to be of service to you and is in a position to render such service. We want you with us. The Treasurer, John H. McClellan, Harrison Technical High School, Chicago, Ill., will be glad to hear from you.

A NEW SERVICE DEPARTMENT.

The Central Association of Science and Mathematics Teachers is inaugurating a new department—the Service Department. It has always been the aim of the Association to render service to its members through its meetings, its magazine, and its printed *Proceedings*, but it desires to be of even greater service in the realm of science and mathematics to the individual teacher.

Purpose.

The purpose underlying the inauguration of this new department is to give the individual teacher, wherever he may be, assistance in solving his problems. D. A. Lehman of Goshen College, Goshen, Ind., Corresponding Secretary of the Association, is the secretary of this Service Department. All inquiries received by him will be referred for answer to various teachers prominent in their lines of work.

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Supplies.—Latest or most efficient apparatus for demonstrating certain problems; special reference books; lists of publications by United States Government; names of reliable supply houses.

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Problems.—Information upon matters involving reference work in Chicago libraries. Solution of practical classroom problems and teachers' "troubles."

Motto.—"The Association Lives to Serve."

Address, D. A. Lehman, Goshen College, Goshen, Ind.

DIRECTORY OF SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the March, June, and October issues of this Journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. Names are dropped when they become one year old.

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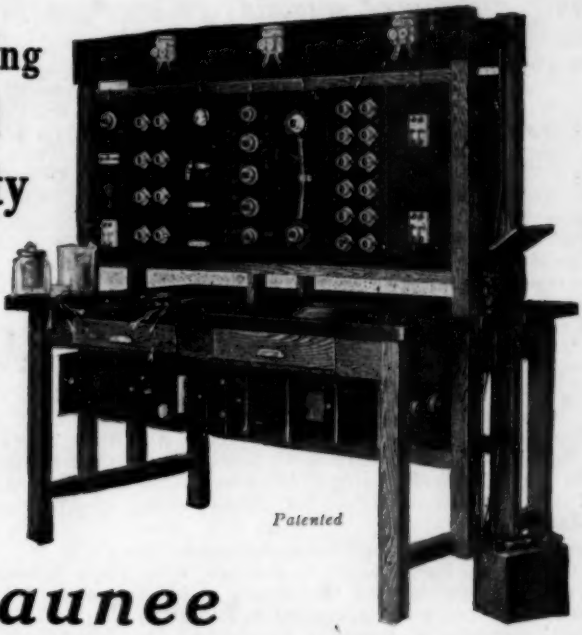

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